THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. IV.

No. XI.—NOVEMBER, 1887.

## ORIGINAL ARTICLES.

### I.—On a new Species of *Eurypterus* from the Lower Carboniferous Shales of Glencartholm, Eskdale, Scotland.

By Henry Woodward, LL.D., F.R.S.

(PLATE XIII.)

SOME time since, in the summer of 1884, Mr. Jex, a collector of fossils employed by Mr. Robert Damon, F.G.S., of Weymouth, obtained from the Lower Carboniferous Shales of Eskdale, a new and most interesting form of Merostomatous Crustacean belonging to the genus *Eurypterus*. It has been secured for the Geological Department of the British Museum (Natural History), and I now propose to submit a brief description of this very interesting specimen.

In my Monograph of the order Merostomata (Part IV. 1872, pp. 133—139, pls. xxv.—xxvii. see also p. 180) I described the only previously-known British *Eurypterus* from the Carboniferous Limestone series, Kirkton, near Bathgate, West Lothian, named *Eurypterus Scouleri*; a specimen doubtfully referred to the same having been since discovered at Cape Breton. Another species not determined was noticed by Salter from the Carboniferous of Nova Scotia. A form doubtfully referred to *E. Scouleri* from the Upper Devonian of Kiltorcan, Ireland, and one named by Salter *E. pulicaris* from the same horizon, St. John's, New Brunswick, and two from the Lower Devonian of Arbroath, namely *E. Brewsteri* and *E. pygmæus*, complete the Carboniferous and Devonian series.

But in the Upper Ludlow beds (U. Silurian) no fewer than 17 species have been described, 10 being from Russia and N. America, and seven from Ludlow, Kendal, and Lanarkshire; but the most perfectly preserved are those from New York and the Island of Oesel in the Baltic.

*Description of the Specimen.*—The specimen is preserved with its dorsal aspect exposed upon the surface of a much-jointed bluish-grey mudstone; owing to shrinkage and the want of tenacity between the matrix and the fossil, much of the black and glistening organic surface of the carapace and segments has been lost in transit. The counterpart however of a portion of the fossil is preserved, and assists us in the interpretation of the appendages, etc.

The head, which is semicircular in outline, is very tumid, and strongly and irregularly tuberculated; the general surface being coarsely squamose and scabrous. The eyes are not visible; but

this I believe to be owing to an unfortunate series of fractures, which intersect the middle of the carapace just where in other specimens these organs are usually situated. There is a distinct and rather wide and smooth margin to the head-shield, which can be traced for about three-fourths of its circumference, but it is broken away upon the right side by the protruding appendages.

Three almost entire jointed appendages, furnished with numerous spines at their articulations and with smaller spinelets along their edges, are preserved *in situ* on the right side of the head. A portion of a fourth is seen on the right anterior border of the carapace; and portions of the corresponding limbs are shown on the left side of the head. The appendages where best preserved show six articulations, the 1st or coxal joint (making 7 articuli) being hidden beneath the carapace. The two body-segments which follow next after the head-shield are unusually large, being one-third as deep as they are broad, and very strongly squamose, the squamæ lying very close to one another and becoming more elongated near the margins of the segments; the posterior angles of each segment were slightly produced, the points being directed backwards. Portions of five other segments following the 1st and 2nd are seen in place on the right side of the specimen, three of which are also partly preserved on the left side.

These show that the 3rd, 4th, 5th, 6th, and 7th segments were much narrower than the preceding two, their depth being only one-seventh of their breadth; the surface-ornamentation too undergoes a considerable change, being sparingly covered with small irregular tubercles.

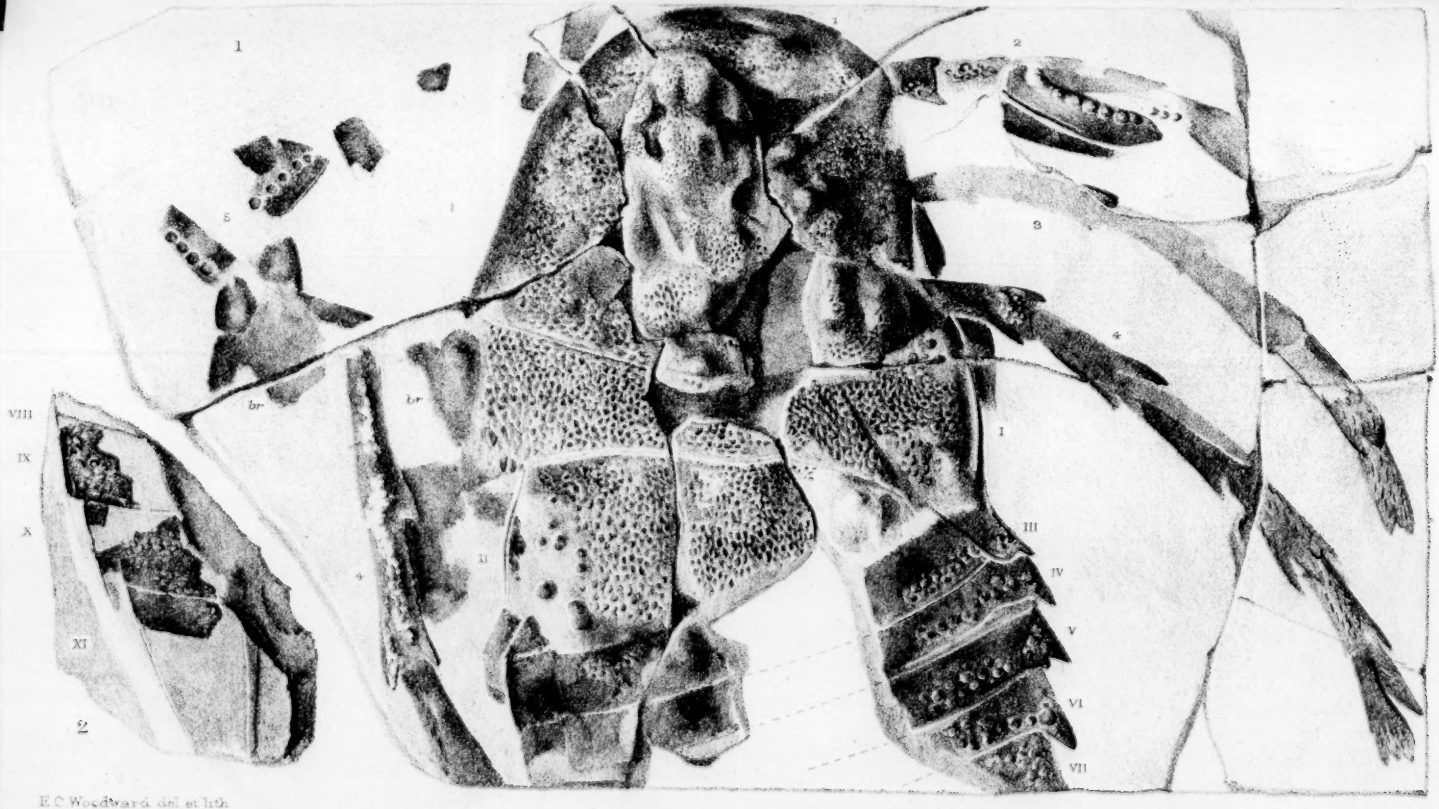
Scattered irregularly over the somites may be seen a number of small circular disc-like bodies, having a radiating fibrous structure, which I at first mistook for some small polyzoon or other minute sessile parasite, fixed to the surface of the Crustacean. A more careful investigation—in which Dr. G. J. Hinde was so kind as to give me his valuable assistance—showed me that these bodies were actually enclosed within the chitinous substance of the tergum, and are in fact deposits of calcite forming part of the crust of the segments themselves.

Under the description of *Anthrapalæmon Parki* (Peach), from the Carboniferous series of Langholm, Dumfriesshire, Mr. B. N. Peach writes as follows[1]:—

"The test is very thin, and probably contained very little calcium carbonate, as it is apt to be filled with *calculi*,[2] such as that now found in the common shrimp. Where the test is thin these are mere scales; but in the spines and thickened portions they are semi-globular, the rounded part being mammilated. In every case, however, they have a central nucleus from which radiations proceed.

[1] See Trans. Roy. Soc. Edinburgh, 1880, vol. xxx. pt. 1, p. 80; see pl. ix. figs. 4*g*, 4*h*.

[2] "Globular calcite." Prof. Huxley informs me that he has noticed this deposit as constantly present within the chitinous test of every *Palæmon* and *Crangon* which he has examined.—H. W.




E.C. Woodward. del. et lith.

West, Newman & Co. imp.

Eurypterus scabrosus, H. Woodw., L. Carboniferous, Eskdale, Scotland.

The above remarks are equally applicable to all the Crustacea described in the present paper. Sometimes these calculi are sporadic, at other times they fill the whole tests of the creatures, forming an irregular polygonal net-work, which destroys the character of the test and gives it a granulated appearance. Even in this case the nucleus and radiations are observable." These calcareous deposits are most carefully figured by Mr. Peach in plate ix. of his memoir, figs. 4*g* and 4*h*. They agree exactly with those observed in the specimen of *Eurypterus* now under description.

In a detached piece, obtained with and forming a part of this same specimen, is preserved the left margin of four other body-segments which must have been parts of the 8th, 9th, 10th, and 11th segments, so that we only need evidence of the 12th segment and the telson to complete our knowledge of this specimen.

These posterior segments give clear evidence of becoming narrower and deeper as they recede from the head—the 9th being about five times as broad as deep; the 10th being about four and a half times as broad as deep; the 11th being about twice as broad as it is deep. There is the mould of a raised longitudinal subcentral ridge, one evidently of a pair of ridges no doubt present on each of the posterior body-segments as seen in *Eurypterus remipes* (De Kay) from North America.

The fifth pair of broad spatulate swimming-feet answering to the maxillæ, or to the maxillipeds of the higher Crustacea, are not preserved in this fossil; but as they have been found with nearly all the species of *Eurypterus* hitherto described, there is little doubt that this form also possessed them when entire. Certainly the other appendages reproduce with only slight modification in their style of ornamentation those of the Russian, the American, and the Lanarkshire *Eurypteri* already described and figured by Hall, Schmidt, and myself. Certain delicate brown leaf-like bodies can be observed lying on the left side of the head. There can be no question that these are the remains of the branchiæ, such as I have figured from Lanarkshire, and such as are frequently found lying detached on pieces of shale from Eskdale, and which have been considered by Mr. Peach to have belonged to some form of Arachnide?

Prof. Geikie indeed states that "Mr. Peach's researches go to show that the Carboniferous *Eurypterus* was almost certainly a gigantic Arachnid and not a Crustacean. Some splendid specimens of its scorpion-like combs and feet have been obtained from the Lower Carboniferous rocks of the South of Scotland" (Geikie's Text-Book of Geology, p. 724, Second Edition, p. 723.)

The scorpion-like combs I have not seen, but I cannot for a moment doubt that the feet of this specimen are those of a true Eurypterid, and although the pair of swimming-feet are not preserved, the form of the body-segments and their squamate ornamentation proves that this was a true aquatic form, and that the fragmentary leaf-organs lying beside it were remains of its branchial lamellæ.

Of course—if the *branchiated* aquatic forms of the Merostomata,

are to be relegated to the same division as the terrestrial *tracheated* forms of the Arachnida, there is no need to offer any further evidence; but at present I deny, with other Carcinologists, that Professor Ray Lankester has proved his position, or that such an arrangement is consistent with sound zoological classification.

It is extremely interesting to record the fact that in 1881 Mr. J. F. Mansfeld communicated an account, with a woodcut, of a fine fossil *Eurypterus* found by him in the shale immediately beneath the Darlington Cannel Coal-bed, Lower Productive Coal Measures, Darlington, Pennsylvania, U.S.A. (See Amer. Phil. Soc. Proc. vol. xix. p. 152, April 1st, 1881.)

The figure I have seen, being only a sketch, and roughly executed —without scale—does not admit of accurate comparison; but so far as I am able to judge, this American *Eurypterus* must have been extremely closely related to our Eskdale species.

As it is convenient to have a name for a new form, I propose to designate this our second Scottish *Eurypterus* from the Carboniferous series as *E. scabrosus*.

*Dimensions of Specimen.*—Head $5\frac{3}{4}$ inches broad, by $4\frac{1}{2}$ inches in length. Length of body (including head to seventh segment) 10 inches, perfect appendage 8 inches in length, widest part at third segment of body $6\frac{1}{2}$ inches broad. Total length estimated at about 20 inches, including the telson.

EXPLANATION OF PLATE XIII.

*Eurypterus scabrosus*, sp. nov.

Fig. 1. Larger slab containing the head with three of the gnathopodites in place on the right side; and the 1st to the 7th somites more or less perfectly preserved. Fragments of the branchial leaves (*br.*) are seen on the left side of the head. Prof. Huxley (who kindly looked at the original specimen) has suggested that the portion of an appendage, with a row of small tubercles along its border near the small figure 2, on the right side of the head, may possibly have been a part of a chelate appendage; but it is very obscure. Other fragments are seen on the left side of the head (near 5) similarly ornamented.

Fig. 2. A fragment of same specimen showing portions of the 8th to the 10th somites.

---

## II.—On the Origin of certain Banded Gneisses.

By J. J. H. Teall, M.A., F.G.S.

(PLATE XIV.)

THE term gneiss as generally used by geological writers signifies a rock of granitic composition in which a parallel structure in the arrangement of the constituents is more or less apparent. For our present purpose it is important to note that other plutonic rocks besides granite (*e.g.* diorite, gabbro, and peridotite) have their gneissose equivalents, so that, if we use the term gneiss in a structural rather than in a mineralogical sense, we may speak of diorite-gneiss, gabbro-gneiss, and so on.[1] Now the parallel structure of gneissose

[1] Roth has recently (Sitz. d. k. preuss. Akad. d. Wissen. Ueber den Zobtenit, vol. xxxii. 1887, p. 611) proposed that Leopold von Buch's term Zobtenfels should be revived under the form Zobtenite for those gabbros which are associated with crystalline schists and are often foliated.

FIG. 1.—Granite veins in diorite, Pen Voose, the Lizard.

FIG. 2.—The "Granulitic Series," Pen Voose, the Lizard.

To illustrate Mr. J. J. H. Teall's paper on Banded Gneisses.

rocks is of two kinds. It may consist (1) of a parallel arrangement of certain constituents (*e.g.* mica plates or porphyritic felspars), or (2) of an alternation of bands of varying chemical and mineralogical composition. It is agreed on all hands that a parallel structure of the first kind may be due either to the deformation of a mass of half-consolidated plutonic rock at the time of intrusion, in which case it is strictly analogous to the flow structure in many volcanic rocks, or to deformation produced by earth-stresses operating on the mass after consolidation. As regards the origin of the second kind of parallel structure there is no such general agreement, and many writers regard it as due to some process akin to sedimentary deposition. The object of the present paper is to show that just as the first kind of parallel structure may be and in certain cases actually is due to the plastic deformation of what may be termed homogeneous[1] plutonic masses, so the second kind of parallel structure (banded structure) may be and in certain cases actually is due to the deformation of heterogeneous plutonic masses.

In the first place let us inquire what kind of deformation is necessary in order to produce parallel banding in a heterogeneous mass. A moment's consideration will show that if any heterogeneous mass of fairly uniform dimensions in the different directions be deformed into a flat sheet or narrow ribbon, then the individual portions will be similarly deformed and the mass as a whole will show a banded structure. This was clearly realized by Mr. Poulett-Scrope in 1824, who not only explained in this way the parallel banding of the Ponza liparites, but also suggested that the similar appearances in gneiss and schist might be due to the same cause.[2] A very simple experiment will serve to illustrate the important fact just referred to. Take pieces of differently coloured clays (say ordinary potter's clay and clay which has been intimately mixed with the blue used by laundresses) ; bring them together in any way you please so as to make one lump and deform the lump into a thin sheet or narrow band by squeezing or rolling. Then fold the sheet or ribbon on itself two or three times and, if you like, repeat the process of rolling it out. In this way the most perfect parallel banding may be produced and by varying the conditions in ways which readily suggest themselves (as for example by using clays of different degrees of plasticity and inserting fresh pieces after the deformation has progressed to a certain extent) it is easy to produce many of the peculiar structures seen in banded gneisses.

It is important to note that the result will differ according as the mass is deformed into a flat sheet or narrow strip. In the former case the strain-ellipsoid will be an ellipsoid of revolution with its short axis in the direction in which the stress was applied, in the latter case the strain-ellipsoid will possess three unequal axes, the least axis lying approximately as in the former case, and the greatest axis lying at right angles to this and in the direction of

[1] Not homogeneous in the strict sense of the term, but homogeneous in the sense that the different mineralogical constituents are uniformly mixed throughout the mass.

[2] Geology of the Ponza Isles, Trans. Geol. Soc. London, 2nd ser. vol. ii. p. 228.

the length of the strip, *i.e.* in the direction of stretching. The idea of a strain ellipsoid is of course only applicable to those masses or portions of a mass which have been subjected to a uniform strain.[1] If the different coloured clays yield differently to the deforming stresses the phenomena will be highly complex.

Now before we are justified in looking favourably on the theory I am endeavouring to illustrate, it is necessary to show, (1) that banded gneisses are on the whole identical with plutonic rocks in composition, (2) that masses of plutonic rocks are often heterogeneous, and (3) that heterogeneous masses, if such exist, may be deformed in the manner required to produce banded structures.

To establish the first point it is only necessary to refer to Roth's elaborate collection of rock analyses.[2] No one who has studied these analyses can doubt for a moment that the banded gneisses are essentially identical with plutonic rocks so far as chemical composition is concerned. The resemblance, however, is not limited to chemical composition, it extends to mineralogical composition and in a certain sense even to structure. Each plutonic rock has its equivalent in the banded gneisses.

We pass on now to consider the second point. When large masses of plutonic rock are examined they are often found to vary considerably in composition. They frequently contain patches which differ from the main mass. These have been investigated by Mr. Phillips, so far as the granites are concerned, and have been shown by him to be in general more basic in composition than the rock in which they occur. Again, every one is familiar with the phenomena of contemporaneous or segregation veins. These appear to be in general more acid than the rock in which they occur. Sometimes two or more varieties of plutonic rocks interlace in the most intricate manner. Cases of this kind have been described by Prof. Judd[3] as occurring in the Isle of Rum, where basic and ultra-basic rocks are concerned; by Messrs. Peach and Horne[4] as occurring in the Shetland Isles, where granite and diorite are concerned; and by Herr Lossen[5] in the Hartz, where granite (granitite) and gabbro are concerned. The last-mentioned observer states that both granitite and gabbro occur in the same dyke, and that the acid rock either surrounds or penetrates masses of the basic rock in the form of veins—the relations of the two rocks being such as to suggest that the two magmas were intruded simultaneously (or nearly so) rather than that the fluid granite-magma was injected into solid gabbro.

Diorite and granite may be seen in intimate relation in the ridge

[1] A mass is said to have been strained uniformly when every portion has been strained alike.

[2] Beiträge zur Petrographie, etc. Abh. d. k. preuss. Akad. d. Wissen. für 1869, 1873, 1879, and 1884.

[3] On the Tertiary and older Peridotites of the West of Scotland," Q. J. G. S. vol. xli. p. 358.

[4] The Old Red Volcanic Rocks of Shetland, Trans. Royal Soc. Edinburgh, vol. xxxii. part ii. p. 373.

[5] On the Eruptive Rocks of the Hartz, Jahr. d. preuss. Geol. Landesanstalt für 1882, p. xxi.

of crystalline rocks running E. and W. a few miles south of Haverfordwest, in Pembrokeshire, and similar rocks show similar relations in the Lizard peninsula. The last-mentioned case will shortly be described at greater length.

We have now to consider the question of deformation. No one will doubt that deformation necessary to produce banded structures in heterogeneous plutonic magmas may take place in connexion with intrusion. The only question that can arise is whether many banded gneisses have originated in this way. At present I have no definite opinion on this point. There is, however, another way in which the necessary deformation may be produced, viz. by the operation of the earth-stresses of which we have such striking evidence in mountain-regions. With reference to this mode of deformation I will content myself by referring to the work of Heim and Baltzer in the Alps, of Reusch in the Bergen peninsula, of Lehmann in the granulitic region of Saxony, and of Lapworth and the Geological Survey (Messrs. Peach and Horne) in the north-west of Scotland. It will not be doubted by any one who has studied the writings of these authors, and is at all familiar with the phenomena they describe, that large masses of country have been profoundly modified by the earth-stresses. It may be a long time before we become acquainted with the precise nature of the movements and deformations, but that they are adequate to convert a heterogeneous plutonic mass into a banded gneissic series is to say the least highly probable. It must of course be remembered that sedimentary rocks may also be involved in the movements, so that the occasional presence in a gneissic series of bands having the composition of sedimentary rocks is no proof that the whole series is of sedimentary origin.

Having by these general remarks established, as I believe, the *a priori* probability of the theory I am endeavouring to illustrate, I will now refer to what appears to me to be a case in point. In the Lizard district of Cornwall we find two or three rock-types occurring as portions of an igneous complex and as portions of a banded gneissic series. Where they exhibit the relations of igneous rocks (Fig. 1, Plate XIV.), they may be termed granite, diorite and gabbro; where they occur as portions of a banded gneissic series they possess the same specific gravity, but usually show a more or less marked parallel structure and in certain cases differ in mineralogical composition. Consider first of all the petrographical characters of the different rock-types.

*Granite.*—This rock never occurs in large independent masses, but only as comparatively small veins and dykes. It is found in gabbro (north of Pen Voose), serpentine (Kynance) and diorite (Pen Voose). It is present also, in a somewhat modified form, in the banded gneissic series—the "granulitic series" of Prof. Bonney.[1] The least modified rock is a fine-grained granular aggregate of quartz, felspar and dark mica. The felspar is mostly unstriated, but a striated variety also occurs. Both felspar and quartz are

[1] Quart. Journ. Geol. Soc. vol. xxxix. (1883), p. 1.

present for the most part in irregular grains. Sometimes, however, we find more or less rounded grains of quartz inclosed in the felspar, so that the quartz was not always the last mineral to form. The mica is deeply coloured. It occurs in detached scales and also in aggregates composed of several individuals. Sections parallel to the vertical axis appear a pale yellowish-brown when viewed with rays vibrating at right angles to the cleavage cracks, and opaque or a deep reddish brown when viewed with rays vibrating parallel to these cracks. The mineral is biaxial with a very small optic axial angle. It evidently contains a considerable amount of iron, for the rock in which it is abundant often assumes a deep red colour by weathering. The mica of the weathered rocks has been replaced by chlorite with which iron-oxides are associated.

The more modified rocks, and these are by far the most abundant, are characterized by the presence of a fine-grained granulitic aggregate of quartz and felspar and a more or less marked parallel structure. The granulation of the quartz and felspar is, I believe, a secondary phenomenon due to the dynamic metamorphism which has operated upon the district. It may be developed merely at the margin of the original grains, in which case we have the mortar-structure of Tornebohm [1]—the relics of the original grains then lie in a fine-grained granulitic paste like stones in mortar—or it may replace entirely, or almost entirely, the original quartz and felspar. The development of white mica does not appear to be a common feature. It may, however, be observed in what I am inclined to regard as a schistose granite from Porthalla, where it occurs along the planes of schistosity. In this rock the secondary granulitic aggregate forms a large portion of the mass.

A very interesting variety of gneissose rock occurs in the serpentine near Kynance. It forms only a thin band, and is, I believe, a granitic vein which has been profoundly modified by the regional metamorphism. Sections at right angles to the foliation show a magnificent micro-flaser structure. The secondary aggregate of quartz and felspar winds in and out amongst the relics of the original grains, and possesses in some places a crypto- rather than a micro-crystalline structure. The rock does not possess any very definite schistosity and white mica is absent. It appears as if the development of white mica were connected with movement along definite planes—where the mass has been deformed in a plastic manner white mica is absent.

The specific gravity of the rocks of the granitic type lies between 2·6 and 2·7

*Diorite.*—This rock, like the granite, never occurs in large independent masses. It is generally veined by the granite or intimately banded with it in the gneissic series. It may also be found in the gabbro. The rocks to which I here apply the term diorite vary in composition and specific gravity. Some belong to the intermediate, others to the basic series. At the one end of the series we have a

[1] Naagra ord om granit och gneiss. Geol. Fören. i Stockholm Förhandl. 1881, pp. 166 u. 233.

rock which may be termed a mica-diorite, with a specific gravity of about 2·75; at the other end of the series we have a rock which may be termed hornblende-diorite (basic diorite, or possibly an epidiorite) with a specific gravity of 2·99; between the two extremes we find intermediate forms which may be termed mica-hornblende-diorites. The specific gravity of one of these is 2·83.

The more important minerals of the dioritic group of rocks are felspar (mostly striated in the least modified rocks), dark mica, green hornblende, sphene, iron-ores, and apatite. The felspar of the least modified rocks is often somewhat turbid, and the turbid portion frequently forms a kind of kernel in the centre of a comparatively unaltered individual. This points to an original zonal structure. Some of the diorites are porphyritic, and traces of the forms of the porphyritic crystals (felspars) are preserved even in the foliated rocks.

The mica is similar to that of the granite. It occasionally contains minute granular inclusions (probably zircon) which are surrounded by very dark borders. The sphene is a very interesting and important constituent of the diorites. It occurs in perfect crystals and also as grains. The grains in certain rocks form a border to the opaque iron-ores. This is a feature which may be observed in some of the gneissic rocks of Sutherland and the Malvern Hills. Iron-ores are comparatively rare in the mica-diorites, but they become abundant in the basic diorites. Apatite is very common in some of the mica-hornblende-diorites.

The felspars of the diorites show the same tendency to granulation as those of the granite and the individual grains in the granulitic aggregates are mostly untwinned. In the foliated diorites of the banded gneissic series striated felspar is comparatively rare.

*Gabbro.*—As this rock and the modifications which it undergoes when subjected to regional metamorphism were described at the last meeting of the British Association,[1] it will be unnecessary for me to enter into details on the present occasion. Suffice it to say that every gradation from a massive rock to a gabbro-schist may be observed in the district. Unaltered gabbros are, however, very rare, just as unaltered granites and diorites are rare. Since my last paper was read I have isolated the felspar and augite of the unaltered gabbro from Coverack, and Mr. Player has kindly analyzed them for me in my laboratory; the former is a somewhat basic labradorite; the latter possesses ·6 °/₀ of chromic oxide, and is therefore a chrome-diopside. The hornblende of the gabbro-schist from Pen Voose has also been analyzed by Mr. Player. It possesses over 10 °/₀ of alumina and differs from the augite also in containing more magnesia than lime. It contains, however, decided traces of chromium. The analyses, therefore, so far as they go, point to the conclusion that the hornblende differs from the augite or diallage in composition, so that the disappearance of the pyroxene and the development of hornblende cannot be ascribed to simple paramorphism. The specific gravity of the chrome-diopside is about 3·22, that of the hornblende

[1] Geol. Mag. Decade III. Vol. III. p. 48.

is about 3·05. With regard to the so-called saussurite, I am able to state that malacolite, felspar, and minute granules of sphene often occur as constituents. The malacolite has been isolated and analyzed by myself, so that no doubt exists as to its identification, though it often occurs only in minute grains without form or cleavages. The doubtful substance which appears white by reflected and brown by transmitted light and which is a constant feature in the Lizard saussurite has not been identified.

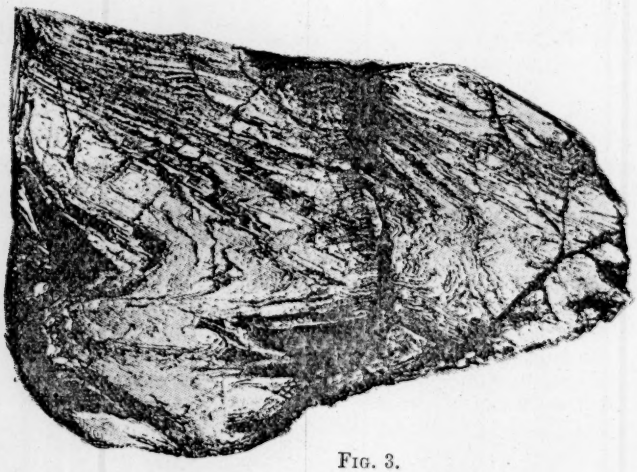


Fig. 3.

We have now to consider the mutual relations of the different rocks above described. At Kennack Cove and at Pen Voose, near Landewednack, granite may be seen veining diorite, often in the most intricate manner (see Fig. 1, Plate XIV.). At Pen Voose, veins of both granite and diorite occur in the gabbro, Fig. 4. The three rocks are therefore of igneous origin. They exhibit the relations of igneous rocks, and they possess the composition of igneous rocks; moreover, it is possible to find here and there portions which have escaped the influence of the dynamic metamorphism, and which show the normal structure of igneous rocks. But the same rock types occur as integral portions of a banded gneissic series in the same localities. The bands are in some places as regular as layers of sediment in a stratified rock-mass, in other places they are crumpled and contorted (Fig. 3); in others we observe "eyes" and lenticles of diorite surrounded by streaks and bands of a granitic rock (see Fig. 2, Plate XIV.)

As a rule the banded gneissic series is formed only of granitic and dioritic rocks, but we occasionally find eyes and streaks of gabbro and gabbro-schist. One large specimen, to which I wish to direct special attention, shows a crumpled band of gabbro-schist in mica-diorite.

Another mass much too large to carry away showed the appearance

represented in Fig. 5. It consisted of parallel bands and narrow lenticles of foliated gabbro, granite and diorite. Fig. 6 represents the relations of granite, diorite, and gabbro in a mass which exhibited no parallel structure. In Figs. 5 and 6 the space left clear represents granite, or at any rate a rock of granitic composition; the dotted portions represent diorite, and the portions indicated by fine

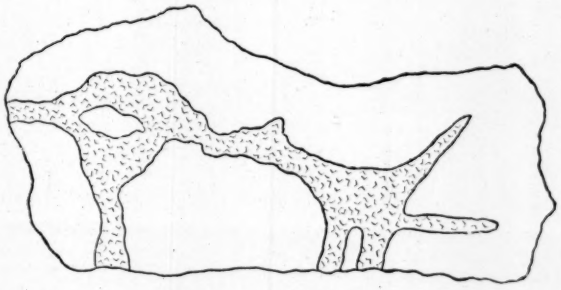


Fig. 4. Granite in Gabbro, Pen Voose. Block 6 feet long.

lines gabbro or gabbro-schist. Fig. 5 represents a mass four feet and Fig. 6 one three feet in height.

I submit, therefore, that the rocks of the Lizard District referred to in this communication, and which constitute the greater portion of Prof. Bonney's granulitic series, are of igneous origin and that the parallel structure which characterizes many of them has nothing

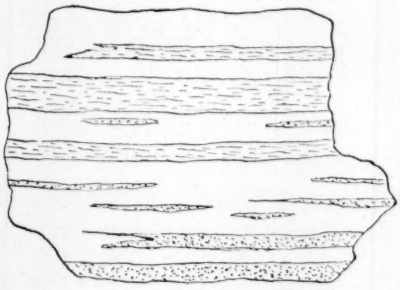


Fig. 5.

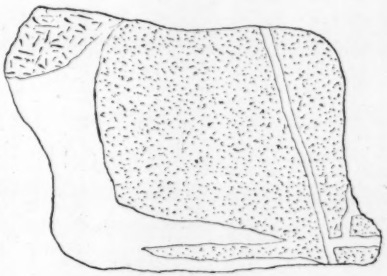
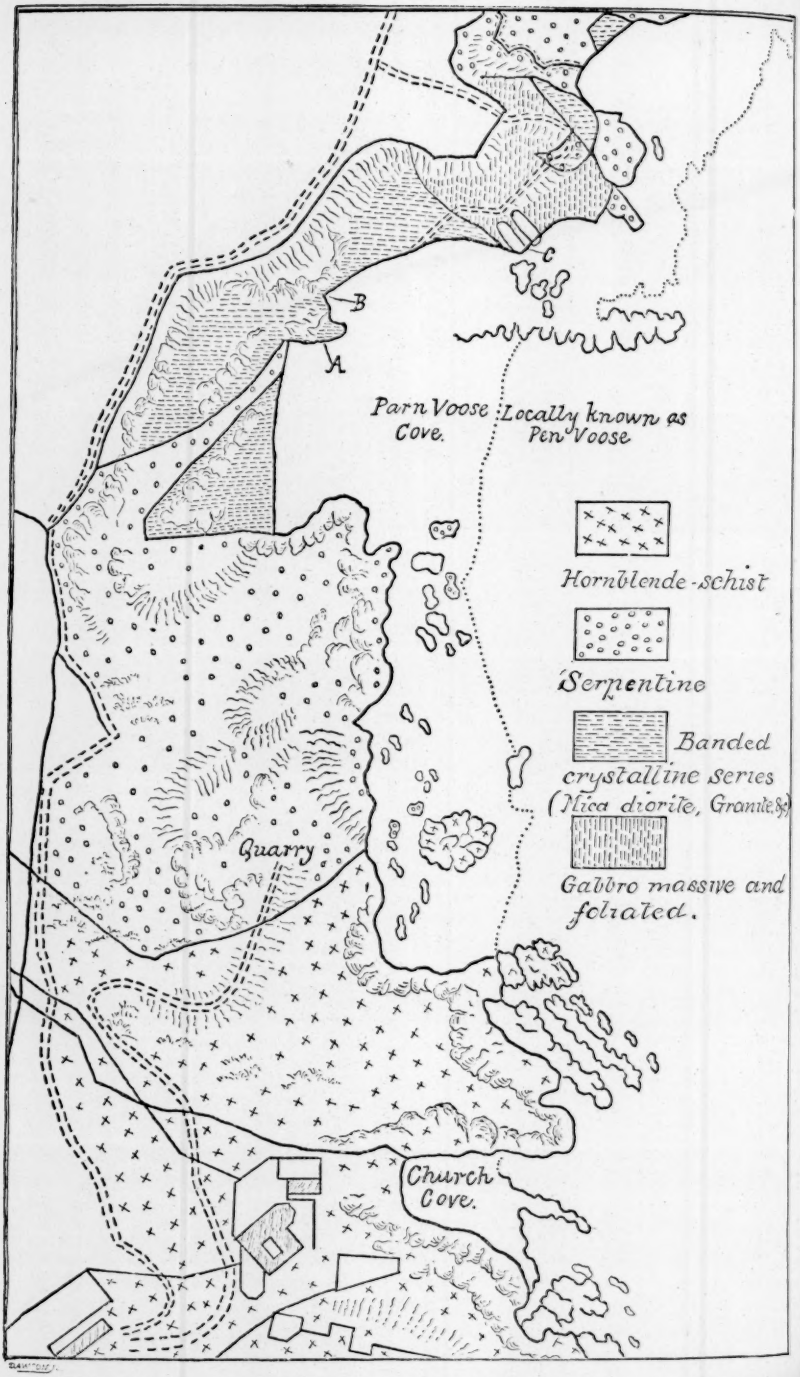


Fig. 6.

to do with stratification in the ordinary sense of the word, but is a consequence of the deformation to which the original rock-masses have been subjected. It is undoubtedly true, as Prof. Bonney has pointed out, that many of the rocks are largely composed of broken crystals, and may be said therefore to possess a clastic structure if we use the term clastic in its etymological sense. But this is no proof that the fragments have been deposited as such. The original minerals may have been broken during the deformation of the rock-masses. This I believe is what has actually taken place.




Geological Map of Coast near Landewednack. Scale 25 inches to the mile.
To illustrate Mr. J. J. H. Teall's paper.

The structures are of the kind for which Prof. Kjerulf[1] has proposed the term cataclastic.

I doubt whether any true clastic (epiclastic[2]) rocks occur in the Lizard District south of St. Keverne.

### EXPLANATION OF ILLUSTRATIONS.

The map is merely intended to enable readers to form some idea of the relations of the rocks in the district especially referred to in the latter part of the paper, and to fix the exact localities from which the illustrations are taken. The actual phenomena are too complicated to be accurately represented even on the 25 inch scale At the point marked A an "eye" of gabbro foliated at the margin and measuring about five or six feet in length may be seen in the "granulitic" series. Figs. 2 and 3 are reproductions from photographs taken at B. Fig. 5 represents a portion of the cliff face about nine feet in height; Fig. 6 another portion about four feet. The crumpling of the bands is well seen in the negative, but has not been very successfully reproduced in the figure. Fig. 1 is from a photograph taken at C, where the banded gneissic series and the gabbros are seen in juxtaposition. It represents a portion of the cliff about 8 feet in height. The line representing the boundary between the gneissic series and the gabbro should have been brought to the point C. This figure illustrates very well the manner in which the light-coloured granitic rock veins the dark-coloured diorite. It must be remembered that Figures 1, 2, and 3 represent portions of the same rock mass. If the rocks are igneous at C as seems to be proved by Figure 1, they must also be igneous at A and B. The point C is the point where a granite vein is indicated on the geological map of the district.

---

## III.—Elements of Primary Geology.[3]

By T. Sterry Hunt, M.A., D.Sc., LL.D., F.R.S.

1. UNDER the general terms of Primary and Original, given by Werner and others, to the early crystalline rocks, have been included various mineral aggregates which may be classed under three heads: 1. The great stratiform masses of aqueous origin, essentially granitic, and formed by slow deposition at the earth's surface, which I have called Indigenous rocks. 2. Those lesser crystalline masses which were formed under similar conditions to the last, but within veins or fissures in pre-existing rocks, and may therefore be called Endogenous. 3. Rocks resembling the last in their geognostic relations, and often confounded with them, but distinguished by the fact that they have come into their present positions not by deposition from solution, but by displacement in a more or less fluid or plastic state. These Exotic or erupted masses, whether ancient or modern, are in a sense Primary, since they sustain, in one way or another, intimate relations to the more ancient rocks to which this name was first given.

[1] Grundfjeldspsrofilet ved Mjøsens sydende, Nyt Magazin, 1885, p. 215.

[2] Some modification in the use of the term clastic is rendered necessary by recent discoveries. I venture to suggest that it should be applied to all rocks which consist largely of mineral fragments and that we should distinguish between the three types of clastic rocks at present recognized by using the terms epiclastic, cataclastic, and pyroclastic. *Epiclastic*—Rocks formed of fragments resulting from the breaking up of older rocks occurring *upon* the earth's surface. *Cataclastic*—Rocks largely composed of fragments produced during the deformation of older rocks by the earth-stresses. *Pyroclastic*—Fragmental rocks of volcanic origin. The same terms may be applied to the structures which characterize the rocks in question.

[3] Paper read before Geological Section, British Association, Manchester, 1887.

2. The history of the origin of all these rocks is one of evolution through successive differentiations. The transformations of the primitive igneous material of the earth's crust, through the action of air and water, aided by internal heat, present a mineralogical evolution not less regular, constant and definite in its results than the evolution apparent in the organic kingdoms. The nature of this very complex operation, and its various stages, the writer has elsewhere endeavoured to set forth at length, and the object of the present note is to state concisely, and in an elementary form, some conclusions and generalizations reached after forty years of study; referring the reader for details to his recently published volume entitled *Mineral Physiology and Physiography*. It may, however, be said in a few words that the protoplasmic mineral matter—which we may define as the superficial portion of a cooling globe solidifying from its centre—was, so soon as its surface became sufficiently refrigerated, the subject of a double series of processes. These included (1) the removal from its mass by solution, through permeating waters, of the elements of the Neptunian, or as I have elsewhere named them, the Crenitic, crystalline and colloidal or porodic aggregates; (2) the modification of the residue by this watery lixiviation, removing silica, alumina and potash, and when sea-water intervened, bringing in lime, magnesia and soda in exchange; and farther by the crystallization and partial differentiation through the influence of gravity, and by eliquation, of more or less altered portions of this primitive mass, resulting in the production of various types of properly igneous or plutonic rocks.

3. The continued removal therefrom of the elements of the great succession of crenitic rocks, which were laid down upon its surface alike as indigenous and endogenous masses, caused a progressive diminution in volume in this water-impregnated primitive plutonic stratum; which must not only have produced a profound corrugation of its earliest crenitic envelope, but through the succeeding ages of the duration of this operation, have given rise to that generally folded and inclined attitude, with frequent discordances, which characterizes the Primary stratified rocks, while it is only occasional and accidental in Secondary strata. With the decline of crenitic action the weight of accumulated strata apparently brought about the plutonic and pseudoplutonic eruptions; which appear to have been rare in the earlier periods, but in later times to have replaced the previously continuous upward transfer of matter from the primitive plutonic substratum by the process of aqueous solution. In thus indicating what must have been in early periods a potent agent in producing corrugation and disturbance of strata in the crenitic rocks, it must not be forgotten that from the beginning to the present time the contraction of the terrestrial anhydrous nucleus from secular refrigeration has also doubtless been a factor therein not to be overlooked.

4. The crenitic masses present in successive ages marked variations in mineral type, which furnish the basis of a chronological classification having regard especially to the relative proportions of silica,

alumina and alkalies in the masses. In the study of these rocks as members of great succeeding groups, it is however necessary to take account of the products, alike soluble and insoluble, of the subaerial decay of previously exposed masses, both crenitic and plutonic, of the frequent intervention of sea-water bringing magnesian salts, and also of the direct and indirect intervention of products of organic life; all of which have caused at different periods variations in the constitution of the rock-masses generated. From these considerations it will be apparent that no series of deposits subsequent to the ancient granitoid gneisses can ever have possessed the same degree of uniformity and of universality as they. Variations from causes already assigned appear also in the constitution of the plutonic rocks of successive ages.

5. Types of silico-aluminous crenitic rocks which are rare at a given period become more abundant in a later time, and subsequently disappear. The earlier types recur locally and less well characterized in later ages. From this it results that in the mineral as in the organic world, generalizations as to chronological classification must be based upon the mineral characters of the group considered as a whole, and not on those of individual varieties. Rocks not including aluminous silicates,—such as quartz, carbonate of lime, iron-oxyds and protoxyd silicates,—recur with slight variations at very widely separated periods in geologic time.

6. The operations of solution and deposition, and those of subaerial decay and disintegration during the earlier ages went on under geographic conditions not very much unlike those of later periods, so that in the great series of crenitic rocks certain groups are often absent; in some cases from non-deposition, and in others from subsequent erosion connected with movements of elevation and depression. From these causes, as well as from the universal contraction of the underlying plutonic stratum, due to the crenitic process, stratigraphical breaks and discordances exist among the crenitic strata as among the sedimentary rocks of later ages. All such phenomena in stratigraphy, at whatever period recurring, are however but local and accidental interruptions of the normal order of mineralogical development.

7. The great groups of stratiform crystalline rocks, which everywhere appear as the substratum of the uncrystalline sediments, are essentially neptunian or crenitic in origin, and the few plutonic masses of pre-Palæozoic age have no other significance in the lithological history of these groups than that which comes from the fact that portions of these plutonic masses, or the results of their subaerial decay, occasionally intervene in the formation of the crenitic rocks. Their importance as factors in primary geology is so small that their exclusion therefrom by Werner and his school was an error much less grave than those of the endoplutonic and exoplutonic schools, and especially of the latter; which, in its extreme and logical form, assigns an eruptive origin to the whole category of crenitic rocks, including gneisses, norites, steatites and serpentines, and even quartzite, iron-oxyds and limestones.

8. If we restrict the term eruptive to such rocks as have evidently come in a fused or plastic condition into their position among and above previously formed masses, we may on mineralogical grounds divide them into two classes.

I. Rocks consisting essentially of basic silicates, including much alumina, lime, magnesia, and ferrous oxyd, of which dolerite is the type. These we regard as portions of the primitive plutonic mass, which however, as already explained (§ 2), has, through successive ages, become more or less modified alike by additions and subtractions through the crenitic process, and by crystallization and partial eliquation, thereby giving rise to the considerable variations in composition met with in these basic rocks in different areas and in different periods. The stratiform arrangement of the elements of these, due to movements of flow, occasionally met with in such masses, simulates, as is well known, the structure of stratified crenitic masses. This has led some theorists to assign to these plutonic rocks an aqueous and so-called metamorphic origin; while the same resemblance has been, alike by endoplutonists and exoplutonists, made an argument for maintaining a plutonic origin for all stratiform crystalline rocks.

II. Besides the basic eruptive rocks, which are to be regarded as truly plutonic, are those mineralogically very unlike masses which resemble in composition the predominant type of the earlier crenitic rocks, and are often confounded with them. Such are the trachytes and the clearly eruptive granites, which, it is maintained, are but softened and displaced portions of older crenitic masses, and may be designated pseudoplutonic rocks.

9. Besides these masses of once softened and plastic material —whether plutonic, or pseudoplutonic and of crenitic origin— which have been erupted after the manner of lavas, there are two other kinds of rock-masses, which, from their geognostic relations, are frequently regarded as eruptive. Of these the first is the veinstones or endogenous rocks—alike quartzose, calcareous and granitic—already mentioned (§ 1), themselves of crenitic origin, and formed, although in fissures or cavities, under chemical conditions not unlike those which gave rise to the greater masses of non-plutonic primary rocks. As regards the second kind of masses above referred to, it often happens that disrupted portions of crenitic rocks have, without softening or change of state, been forced, as the result of local movements, among softer and more yielding strata. Such intrusions of rigid amongst plastic masses have in many cases caused the former to be regarded as rocks erupted after the manner of lavas.

10. In the case of crystalline or colloidal rocks evidently posterior to the enclosing material, the question will therefore arise whether a given mass may be (1) a truly plutonic rock; (2) a crenitic deposit *in situ*, as a granitic veinstone; (3) a crenitic mass from a lower horizon, which by softening and displacement has assumed a pseudoplutonic form; or (4) a portion of rock, either crenitic or plutonic in origin, which, without having itself been softened, has been forced among soft and yielding materials, displacing these.

These various cases, it is evident, introduced certain apparent perturbations into the normal order of crenitic rocks, and should be carefully borne in mind. The many evidences of the displacement of previously formed crenitic rocks, alike in rigid masses, and in a softened and plastic condition, are especially worthy of a critical study. A more careful investigation than has generally been made alike of the chemical, mineralogical, and geognostical history of the various silicated rocks, keeping in view all of the above considerations, will, it is believed, serve to correct some of the extreme views of certain geologists of the metamorphic school, as well as those of the plutonists.

11. The process of mineral evolution seen in the succession of the earlier and later indigenous crenitic rocks, and in the veinstones or endogenous rocks of still later periods, has continued, though with progressively diminished activity, through Palæozoic and still later ages down to the present time, as evidenced by the indigenous silicates sometimes found in Palæozoic rocks, and even in the deep-sea ooze and the deposits of certain thermal waters. The transition from the earliest fundamental granite to the predominantly uncrystalline sediments of the Palæozoic age is marked by gradations, so that it is not easy to define the respective limits of what were originally designated Primary, Transition, and Secondary rocks. The terms Azoic, Eozoic, and Palæozoic, are for a different reason equally vague. While organic life undoubtedly existed long before what is called Palæozoic time, we have no evidence that it had appeared when the fundamental granite, that is to say, the basal granitoid gneiss, was laid down; although it is apparent that the formation of certain crystalline silicates was still active in later Transition times, contemporaneous with organic life.

A failure to grasp this conception has led geologists of the Huttonian school to an undiscriminating use of the vague and ill-defined term metamorphism, which, in the interest of a more exact science, it would be well to banish from the language of geology. The extremists of that school have maintained, and still maintain, that the chemical and mineralogical constitution of the crenitic silico-aluminous rock-masses has no constant and definite relation to their age, and that large areas of Secondary sediments have, by a subsequent metasomatic change, been converted into mineral masses undistinguishable from the crystalline strata of the earlier Primary periods. Without referring to the fact that recent and careful geognostical studies have at every point shown the fallacy of the stratigraphical evidences adduced in favour of this assumption, it may be remarked that the whole metamorphic hypothesis is an attempt to substitute a constant intervention of miracle for the orderly and systematic evolution which appears in the mineralogical history of the earth's crust.

The transition above referred to introduces a difficulty into our terminology, since among the crenitic indigenous masses are included both Eozoic rocks and others which are apparently pre-Eozoic. Both the Primary and the Transition of Werner are also included therein.

For this reason the often used word Archæan, from its very vagueness and indefiniteness, is perhaps, in the present state of our knowledge, the most convenient term to designate the more or less completely crystalline or colloidal rocks which preceded the essentially detrital rocks of Secondary time, and by their decay and disintegration furnished the chief part of the material of these.

12. As a result of all these considerations, the author has been led to attempt a subdivision of the Archæan indigenous rocks into several chronological groups, which he has often described elsewhere, and which, in his *Mineral Physiology and Physiography*, are concisely treated in a chapter entitled A History of Pre-Cambrian Rocks. It will therefore be sufficient for the present purpose to recall briefly the great subdivisions there advocated.

I. Under the name of Laurentian are comprised the gneissic rocks of the Laurentides, the Adirondacks, the Highlands of the Hudson, and much of the Rocky Mountains in North America. These rocks are divided, so far as known, into a lower granitoid series, often but obscurely stratified, and without included limestones or quartzites (the Ottawa gneiss) and an apparently unconformable series of gneisses, much resembling the last, but with interbedded quartzites, limestones and iron-oxyds (the Grenville series). The name of Laurentian was originally (in 1854) made to include both of these, without regard to the subdivisions; which were, however, pointed out in 1847, and which we may provisionally designate as Lower and Upper Laurentian. The latter term, afterwards applied by Logan to a succeeding series, otherwise called Labradorian, having been superseded by Norian, the name of Middle Laurentian, which some have erroneously applied to the Grenville series, or upper division of the Laurentian, becomes meaningless.[1]

II. The Norian series, in which stratiform crystalline rocks, granitoid in structure, nearly or quite free from quartz, and composed essentially of basic feldspars, of which labradorite is the type, constituting the rocks known as norite, is our next great division. It, however, includes also occasionally quartzose and gneissic rocks, together with crystalline limestones, and iron-oxyds, generally titaniferous. From the resemblance of these gneisses to those of the Laurentian, and from the few contacts observed, this Norian division is assigned the second place in the succession. The characteristic rocks of this series are often called gabbro, but are widely distinct from the euphotide of the Huronian or Pietre-verdi series, to which this name was first applied.

III. At the base of the Huronian appears in many regions a great series essentially composed of petrosilex, often becoming a quartziferous porphyry, and occasionally interstratified with an indigenous

[1] Inasmuch as these distinctions were first devised and announced by the Canadian Geological Survey, it may here be said that its earliest printed reports on the ancient rocks of the country (those for 1845 and 1846, published in 1847) were prepared from the notes and collections of Logan and Murray, by the present writer after his connection with that Geological Survey in February, 1847, and that all subsequent matters relating to lithology in its reports up to 1872, were either prepared by him or under his direction.

diabasic rock, with sericitic schists, quartzites, iron-ores, and more rarely with limestones. This, which in concert with Dr. Henry Hicks, I have called Arvonian, is the Lower Huronian of C. H. Hitchcock.

IV. The Huronian, which in many regions rests unconformably upon the Laurentian, or upon the Arvonian, constitutes the great greenstone or Pietre-verdi group of the Alps, with its characteristic euphotides, serpentines and chrysolitic and amphibolic rocks. In this series the intervention of sea-water is more evident than in the preceding periods, perhaps for the reason that the sea had become more magnesian from the results of the subaerial decay of erupted plutonic masses.

V. The great series of tender fine-grained gneisses passing into granulites on the one hand and into quartzose mica-schists on the other, makes what I called in 1871 the White Mountain or Montalban series. This in many regions rests directly upon the Laurentian, but it is believed in others to overlie chronologically the Huronian. I say this with all deference to my honoured colleague, C. H. Hitchcock, who, recognizing the fact that the Arvonian and the Huronian are wanting in many regions between the Laurentian and the Montalban, and finding above the latter a series of schists which he refers to the Huronian, maintains that the division is younger than the Montalban. To this I would reply: First, that my observations in the Alps, which are in accord with those of Von Hauer, Gastaldi, and others, are to the effect that the true Pietre-verdi or Huronian comes chronologically between the older and the younger gneisses, which two divisions are there indistinguishable from the Laurentian and Montalban respectively. Secondly, that the Taconian (or Lower Taconic) series, which alike in the Alps and in North America overlies the younger gneiss, has in portions a considerable lithological resemblance to parts of the Huronian, to which its schistose portions are related in character, somewhat as portions of the younger gneisses with mica-schists of the Montalban are to the lower or Laurentian gneisses. Hence it was that Murray, Credner, and for a long time the present writer (who gave the name of Huronian in 1855), confounded the Huronian and the Taconian on Lake Superior.

VI. The great series with quartzites, crystalline marbles, and the iron-bearing schists of that region which, in 1873, I called the Animikie series, is, as I have elsewhere endeavoured to show, identical with the Taconian, for which it was long ago claimed by Emmons, and is distinct from the Huronian alike in geographical distribution and in lithological characters. This Taconian series extends in eastern North America from the Gulf of St. Lawrence to Alabama, including not only quartzites and marbles, but siderite and limonite, and much of the magnetite of Pennsylvania; where it embraces alike the "Primal slates" and the so-called "Altered Auroral and Matinal strata" of H. D. Rogers. It is also the Itacolumitic series of Lieber, in the Carolinas, and constitutes, so far as known, the youngest member of the great succession of crystalline schists. While parts of the Taconian have thus been confounded with

Huronian, there are not wanting portions of its more schistose strata which have a resemblance to certain Montalban rocks. Hence it was that at an early period in the writer's studies he attempted to group Montalban and Taconian under the name (soon after abandoned) of Terranovan. For a detailed account of the whole Taconic controversy, see the author's *Mineral Physiology and Physiography*, and for a more concise statement, but with more new light, "The Taconic Question Restated" in the *American Naturalist* for 1887.

13. The name of Taconian was given to the Lower Taconic of Emmons to distinguish it from his Upper Taconic, which is essentially uncrystalline, and, as shown by its trilobitic fauna, and recognized by Emmons himself, is clearly Cambrian, and is in some regions directly overlaid by Ordovician strata. Beneath the recognized Cambrian, in parts of the North American continent, is a great body of uncrystalline sediments, which I have designated Keweenian. While newer than the Taconian, their relation to the unconformably overlying Cambrian is as yet uncertain.

It is not claimed that the above indicated division of the great pre-Palæozoic or Archæan succession is complete. Further study will probably show that there are other groups, and furnish grounds for subdividing those here proposed. They are, with small help from without, chiefly from the generalizations of a single observer during a period of forty years, and as such are offered as a first attempt at a classification of the stratified crenitic rocks, and as illustrations of the process of mineralogical evolution. It must be remembered that for reasons already assigned (§ 2), none of these groups save the fundamental granite can be supposed to possess the characters of uniformity and universality.

---

## IV.—On Some Brecciated Rock in the Archæan of Malvern.

By T. M'Kenny Hughes, M.A., F.G.S.,
Woodwardian Professor, Cambridge.

THE question of the origin of the Archæan rocks is one of such great interest that it will not be thought unimportant on the one hand to record any facts that may bear upon it, and on the other to examine somewhat severely all the evidence that may be from time to time brought forward on the subject. Among the facts which may be adduced in support of the view that the Archæan rocks are altered sedimentary strata, the occurrence of breccias and conglomerates may well claim a foremost place; and a vast amount of superincumbent theory must rest on a very shaky foundation if there be any doubt whether some of those ancient fragmental beds be true conglomerates or not. The manner of occurrence, the mode of formation, and the character of pseudo-breccias and pseudo-conglomerates become therefore questions of first importance.

What one would be at first inclined to accept as evidence of the conglomeratic character of a bed would be that the included fragments were rounded, and that they were of a different character from the mass in which they were imbedded. I have on a former

occasion[1] discussed this point, and given examples of rocks made up of fragments differing more or less in character from the surrounding matrix in cases in which I was able to offer abundant evidence that these rocks owed their fragmental character to brecciation in place. I explained the pebble-like form of the fragments by the rounding off of the corners which usually accompanies infiltration from the joint surfaces, and further pointed out how the apparent matrix was derived from the alteration of the more finely comminuted portions of the brecciated mass, and from the decomposition of the outside portion of the larger fragments.

I am now able, as the result of observations made at various times on the Archæan rocks of the Malvern Hills, to supplement and extend these remarks.

It might be argued that the modification induced by chemical change within the mass would be likely to affect equally adjoining fragments of the same size, composition, etc., and therefore, that, if the apparently included fragments were of different nature, not only from the matrix but also from one another, this must be accepted as evidence that the mass was made up of bits transported from different rocks and various localities, especially if the pieces could be matched among the members of the underlying series.

It would be pointed out that a volcanic brecciated conglomerate often seems made up of fragments of rock belonging to the very series in which the agglomerate occurs.

In the Archæan rock which rises abruptly from the level of the New Red west of Malvern Link, near the quarries, there are some bands of rock (Fig. A B) answering these conditions, which might easily be taken for a brecciated conglomerate. The included fragments are of various kinds, different from the matrix, and also unlike one another. Some are coarse light-coloured crystalline syenite, others close-grained pink felsitic rock. The matrix is a claret-coloured earthy, homogeneous, felspathic paste, with here and there a coarser or crystalline structure, or a few imperfect felspar crystals and grains of quartz. The fragments are often quite rounded, like shore pebbles. Following the band along its trend we find variations in the size of the fragments, and in the proportion of the different kinds, but otherwise its general character prevails as far as it is exposed.

If, however, we trace this fragmental mass across its trend into the adjoining part of the rock, we find that the fragments cease to be round, and their sides are bounded by the continuation of the joints which affect the whole rock. The claret-coloured matrix disappears, being represented first by thin bands along the outside of the angular fragments, then by mere lines of colour along the joints. The pink felsitic fragments run together, and are at last seen united in a vein (C D) of compact pink felspar-rock, such as is so common in the Malvern Archæan. Where the vein has got much broken up and displaced, we find sometimes, on the margin and at

[1] Geol. Mag. Vol. X. 1883, p. 306, "On the Brecciated Bed in the Dimetian of St. Davids."

the sharper folds, even a commingling of fragments of the vein and surrounding rock.

When, moreover, such fragmental beds are observed to coincide with the trend of the ridges, and with the larger divisions of the series which are supposed to represent original differences in the succession, this may be urged as an argument in favour of the conglomeratic character. But in any folded rock the chief crush is apt to run along and be confined to the central portions of the folds, so that the bands of breccia caused by it must necessarily coincide in direction with the trend of the ridge and the strike of the succession of rocks of which the mass is made up, and any rock having a different texture in successive portions, whether original or superinduced, will, during earth-movements, behave just like a sedimentary rock in which there is a succession of beds of different powers of resistance.

In the Malvern Hills, as so often elsewhere, the axes of folding of the older rocks run slightly oblique to the trend of the ridge.

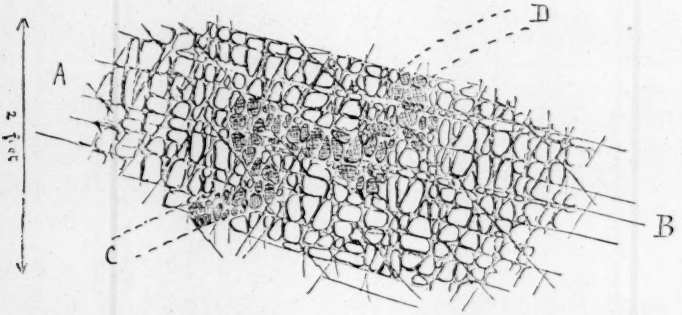



Diagram sketch of part of band of pseudo-agglomerate in the Archæan rocks of Malvern.
*A.B.*—Band of brecciated rock. *C.D.*—Vein of pink felsite.

The margin against which the New Red abuts on the east of the Malvern Hills was probably determined by pre-existing lines of weakness, due to faults and crushes in the Archæan, but the now more important but originally less intense movements which took place after the deposition of the New Red have determined the existing boundary of that series. But the principal divisional planes and sequences indicating the direction of the great folds in the Archæan rock run into the hill obliquely to the margin in the locality to which these observations chiefly refer, namely, the quarries west of Malvern Link. Along these axes, and therefore coinciding with what looks most like strike in the Archæan, run the bands of fragmental rock, and thus, if it had not been that we were able to examine the surrounding rock sufficiently to satisfy ourselves that the conglomeratic character was deceptive, and to see that the breccia passed into jointed rock, we might easily have taken this band as an ancient shingle or agglomerate, to the great confusion of the evidence already sufficiently difficult to unravel.

Thus it is clear that we may in certain cases have a conglomera-

tic-looking mass composed of rounded pieces of rock differing in lithological character both from the matrix and from one another, occurring along what looks like the strike of the rocks, and yet may be able to make out that it is entirely a superinduced structure due to brecciation in place and subsequent decomposition of the broken rock.

From these observations we may also learn another lesson, viz. that crushing may take place without producing any effects analogous to metamorphism properly defined, and may act in aid of true metaporphism or other chemical change, chiefly by comminuting and preparing the rock for chemical reaction.

---

## V.—Archæan Rocks.

By G. H. Kinahan, M.R.I.A., etc.

(Read before the British Association, Manchester, 1887.)

At the present time the American geologists, both those of the United States and the Dominion of Canada, are at variance as to the groups the Archæan should be divided into; it is however unnecessary to enter into this controversy, as the strata may be conveniently grouped, as in Selwyn's map (1884), into *Norians* or *Labradorians*, excessively coarse gneiss or other granitic rocks; *Laurentians*, gneiss and granite; and *Huronians*, schists with subordinate gneiss.

Some of the authorities both in the States and the Dominion would have us believe that the Archæans originally accumulated as crystalline foliated rocks; that is, the minerals were deposited by chemical action from solution. Others, however, hold that at one time they were ordinary sedimentary rocks, which during one or more successive periods of metamorphic action were changed into their present conditions. The present school of English Archæan geologists seem from their writings to coincide with the Americans, who believe in originally crystalline accumulations.

The facts in favour of the first theory seem to be obscure; we are indeed told that "chemistry forbids" an ordinary sedimentary rock changing into a schist, gneiss or granitic rock; yet in the field we can walk along beds that change from unaltered rocks through schist into gneiss, and thence into metamorphic granite. Such a change may be quite contrary to the chemical laws laid down by such Archæan geologists for their own guidance, but they are patent facts effected by the Great Chemist, and to be ocularly learnt by any ordinary observer who carefully works out any large tract of metamorphic rocks.

In connection with this subject the value of lithological characteristics may first be mentioned. It is now generally well known that any rocks, no matter to what period they belong, from the newest Tertiaries to the Archæan, if they have been subjected to sufficient metamorphic action, will be changed into schist and gneiss; that is, that foliation will be developed in them, although originally they may have been ordinary sedimentary rocks, volcanic

rocks, or even granite. Of course rocks that have once been metamorphosed, may again be so placed that they are subjected to a second, third, or even more periods of action; each, if not too excessive, further developing the foliation. The American rocks called Norians or Labradorians have excessively coarse foliation, some of the measured plates being at least a foot in length; these rocks at one time were considered on account of their structure, to be the oldest Archæan: but further research has demonstrated that they are as young, if not younger, than the associated rocks: as they originally were protrudes or intrudes, generally the latter, possibly of granite, into their associated rocks, and that their present structure is solely due to metamorphic action at successive times. In Ireland intruded courses and tracts of granite in the Castlebar District, Co. Mayo, and near Glenties, Co. Donegal, have been altered into a very coarse gneiss by metamorphic action, while in Slieve Croob, Co. Down, the margin of the granite intrude has also by a similar process been changed into gneiss. It therefore appears evident that if any kind of rock, by sufficient metamorphic action, can be changed into crystalline foliated rock, such structure or composition by themselves cannot be taken as a test of the age of the rocks.

Dana, Le Conte, Selwyn, George Dawson, and other American authorities specially point out that between the American Archæan and the later rocks *there are the distinct records of a vast lapse of time.* In the Dominions this is most conspicuous, the unaltered fossiliferous *Primordial* or *Cambriam* rocks lying unconformably on the Laurentian gneiss, and the Huronian schists; the old rocks having been tilted, crushed up, metamorphosed and afterwards excessively denuded, prior to the Primordial or other later rocks having been deposited on them.

In Europe alone there are in different places representatives of the different Passage Beds between the different geological groups; there are, as Passage Beds between the Cambrian and the Ordovicians, the *Arenig group*; between the Ordovicians and the Silurians, there are the *Llandovery* or *Mayhill Sandstone group*; between the Silurians and Carboniferous, there are the *Devonians* or *Old Red Sandstone*, and so on upwards; it is therefore natural to suppose, that somewhere on the face of the globe there are rocks that represent the equivalents of the Passage Rocks between the Archæan and the Primordial; but if such rocks occur in England or Ireland, which to me appears very questionable, they are not the equivalents of any of the American Archæans, and ought not to be so called, but should be grouped as "Passage Beds" under a new and distinct name.

Except in Scotland, where it has been demonstrated by Murchison, there are no authentic records of a great lapse of time between the so-called Archæans and the later rocks. Circumstances have prevented the writer from being intimately acquainted with the English tracts now declared to be of Archæan age; but he has visited some of them, and in fact believes he was the first to suggest that the rocks in one of them might possibly be Archæan. Now, however, since the real Archæan rocks have been seen and studied, such a suggestion in refer-

ence to them, or any other tract of English metamorphic rocks, would be much more cautiously given. With respect to the Irish metamorphic rocks, however, statements can be more confidently made, and to him it would appear that *no rocks in that island are the representatives of the American Archæan, or even of the at present unnamed, or unrecognized, "Passage Beds" between the Archæans and the Primordial.*

Prior to 1878, as has been pointed out in papers published by the Royal Dublin Society and the Royal Geological Society of Ireland, first Jukes and Sterry Hunt, and afterwards Murchison and the writer, pointed out that the equivalents of the Laurentian rocks might exist in places in the provinces of Connaught and Ulster (*Cos. Antrim, Tyrone, Donegal, Leitrim, Sligo and Mayo*). Subsequently Hicks suggested that my supposed Cambrians in Tyrone (*Sliere Gallion District*) were more probably of Archæan age; while still more recently Drs. Callaway and Hull have stated that they have proved the existence of Archæan rocks in different places. But none of the tracts so exalted have the characteristics considered essential by Dana, Le Conte, etc., as *nowhere in Ireland are there records of a great lapse of time between the accumulation of the strata said to be Archæan and those of Cambrian or Ordovician ages.*

As to the rocks at Greenore and Kilmore, Co. Wexford, said to be Archæan, the first are evidently a metamorphic protrude of exotic rocks, and the second are interstratified with their fellows; the rocks in both cases being so intimately intermingled that it is absurd to attempt to separate them; here therefore there is no record of a vast lapse of time between the Archæans and Primordials.

In North-west Ireland, that is, the portions of the Provinces of Connaught and Ulster, between Galway Bay and the eastern boundaries of the Cos. Londonderry and Tyrone, there was one large tract of metamorphic rocks. This has now on it, in places, patches of Silurian and Carboniferous rocks, thus dividing it up into subordinate tracts; yet the connection between all of them is very conspicuous and can be easily traced out.

In Ulster there is an unconformability in these metamorphic rocks; but some of the strata above and below this unconformability have general characters so similar that it is disputed by some; the so-called Archæan are *a portion only of the rocks* below the unconformability. In places both in Ulster and Connaught portions of both the older and later rocks are unaltered, and contain fossils or markings that are considered to be fossils.

In North-west Galway and South-west Mayo, in the unaltered portions of these rock-tracts, there are fossils of Llandeilo types, and after tracing the equivalents of these fossiliferous rocks northward and north-eastward through North-east Mayo, Sligo, and Leitrim, into Donegal, Tyrone, and Londonderry, it induced the opinion, published some years ago (1878), that the later rocks in Ulster, that is, those above the unconformability, represented the upper portion of the Irish Ordovicians (*Volcanic and Slate Series*), and perhaps in part the Llandovery (*Passage Beds between the Ordovicians and Silurians*); while the strata below the unconformability

are the equivalents of the Arenig (*Passage Beds between the Ordovician and Cambrian*) and part of the Cambrian; the lower portion of the Ordovician (*Dark shale series*) being absent. And if the markings near Fintown, Co. Donegal, in the black shales belonging to the rocks below the unconformability (*gneiss and schist series*), which were exhibited at the British Association Meeting, Birmingham (1886), turn out to be Graptolites of Arenig types, as some consider them, *such evidence ought to prove the correctness of this suggestion.* This classification originally was made from petrological or stratigraphical evidence.

The Galway area, declared to be of Archæan age, is as follows. To the south-east granitic-gneiss with metamorphic and intrusive granite; these are margined by gneiss and schist; while in the western portion of the area there are rocks, principally argillaceous, very slightly altered, with intrudes of granite. The south-east granitic-gneiss can be traced, first northward, then north-westward, through schist into the "Doolough bed," in the neighbourhood of Killary Harbour; the latter rocks having in them fossils of Llandeilo types; while westward this granitic-gneiss can be traced through schist into the slightly-altered rocks margining the western coast. The latter rocks have all the characteristics of the "Doolough beds," although fossils have not as yet been found in them.

The supposed boundary of the Archæan area is an arbitrary line drawn nearly westward from Clifden to Oughterard; while both north and south of this line the major portion of the rocks are lithologically identical. *Therefore there are no records of a vast lapse of time.* Stratigraphically it seems proved, *that the so-called Archæans of Galway, instead of being the oldest rocks of the country, are the equivalents of the latest Ordovicians.*

In North-west Mayo (Erris) the tract that has been given a brevet rank is a patch of granite and gneiss, in sub-metamorphic rocks. Here there is a marked distinction between the lithological character of the rocks; but there are no records of a lapse of time, as there is no basal conglomerate in connection with the sub-metamorphic rocks, which the description given in the Geological Survey Memoir has led some to believe. The rocks in this tract have undergone much more metamorphism than those in the adjoining county, which led Griffith to believe they were older; possibly they may be of Archæan age—or the still-unnamed Passage Beds; but it seems more probable that they are of the same age as the rocks in North-east Mayo and South Donegal, which are as much, if not more altered, and whose age probably is either Arenig or Cambrian.

In North-east Mayo, Sligo, Leitrim, and Donegal, there are no hard boundaries to the tracts of the so-called Archæans; as the rocks in general graduate one into another, except in a few places where faults or intrudes occur. So gradual is the change, that the supposed boundaries have several times been changed. In fact, they are like the rolling fences of a farm adjoining a common, one time here and another time a quarter of a mile or more away; yet, in reference to the Archæan boundary, each successive line is

said to be an "undoubted line of a double hiatus ! ! ! the rocks on one side being Archæan, and on the other the equivalents of the Ordovicians." Yet on both sides of such boundaries there are in places identical rocks; this difficulty has, however, been got over by mapping all rocks inside the lines as gneiss, and those outside as schist—regardless of their lithological characters.

If the Fintown markings are not fossils, *all* the rocks below the unconformability may be of any age, from Arenig to Archæan, *but all must be included*, as they are portions of one regular series. They, however, cannot be the American Archæan, but, possibly, under such circumstances (that is, the Fintown markings not being fossils), they may represent the unnamed passage beds between the Archæans and the Primordial.

In the Co. Tyrone, the rocks of the Slieve Gallion district are more or less similar, lithologically, to the Huronians of Ontario. To the south of them there is a well-marked break in time between them and the fossiliferous "Pomeroy beds" (Llandovery ?). Northward they are bounded by schistose rocks that lie on them unconformably; yet, but for this unconformability, the rocks above and below it are lithologically so similar, that they might be considered as belonging to one group. These Slieve Gallion rocks, although having lithological and other characters that might possibly suggest an Archæan age, are evidently, as has been pointed out in previous writings, the eastern extension of the rocks of the Pettigoe District, South Donegal, in which case they belong either to the Arenig or the Cambrian. The Pettigoe rocks in the new classification have not been given a brevet rank, but are said to be the equivalents of the Ordovicians.

The most northern portion of Ireland, Innistra Hull, off Malin Head, Innisowen, Co. Donegal, consists of gneiss. Possibly this may be a bit of the Laurentian Hills, separated by a convulsion of nature and strayed away, to be stranded and find a home off the coast of Ireland. More probably, however, it is of Arenig age.

It should be mentioned that the natural unconformity in the metamorphic rocks of Ulster is treated very cavalierly; as in some places it is recognized and pointed out as "the undoubted proof of the Archæan age of the rocks below it," while in all places where its position proved that the gneiss and schists below it must be portions of one and the same series, it is ignored and is said not to exist. It may also be interesting to record, that the two advocates for the presence of Archæans in Ireland are at variance; as the one rejects the idea of there being Archæans in South-east Wexford, while the other seems to say that there cannot be Archæans in Donegal, as the so-called "Laurentian gneiss" is an intrusive mass.

## VI.—Note on the Affinities of the so-called "Torpedo" (*Cyclobatis*, Egerton) from the Cretaceous of Mount Lebanon.[1]

By A. Smith Woodward, F.G.S., F.Z.S.,
of the British Museum (Natural History).

In a paper read before the Geological Society in 1844,[2] Sir Philip Egerton made known an interesting fossil Selachian from the Cretaceous beds of Mount Lebanon, which he named *Cyclobatis oligodactylus*, and referred to the Torpedinidæ, in consequence of its apparently unarmed skin and the resemblance between its general form and that of the familiar electric Torpedo. Six years afterwards Pictet[3] figured and described a second specimen of the fish, adding some further particulars of the skeleton, and adopting Egerton's determination of its affinities. And quite lately,[4] Mr. James W. Davis has made another contribution to our knowledge of the genus, by describing a larger and more robust species under the name of *C. major*. The fish is again relegated to the Torpedinidæ, and, so far as I have been able to discover, the same original determination has been universally adopted up to the present time.

The fine series of specimens now in the British Museum, however, appear to afford conclusive proof that the imperfections in Sir Philip Egerton's original fossil led to an erroneous interpretation. I have recently determined that the skin was far from unarmed; and a comparative study of the fins has shown that they are totally distinct in character from those of all known genera of Torpedos, while they approximate in a striking manner to those of the "Sting-rays" or Trygonidæ. There seems, indeed, to be no doubt whatever that *Cyclobatis* is truly a member of the last-named family; and there are four principal reasons why this position should be assigned to it rather than that to which it has hitherto been referred. These reasons may be concisely stated as follows.

1. *The pectoral fins are uninterruptedly continued to the end of the snout, and were thus probably confluent in front.* This, as is well known, is one of the main characters of the Trygonidæ, but it is a condition apparently never met with among the Torpedinidæ. I have examined species of all the genera of the latter family, except *Discopyge*, and find that, in no case, do the cartilages of the pectoral fin extend in advance of the antorbital.

2. *The pelvic arch is placed far forwards, and the rays of the pelvic fins scarcely extend posteriorly beyond the extremity of the pectorals.* Though perhaps not of such fundamental importance as No. 1, this peculiarity is much more suggestive of the Trygonidæ than the Torpedinidæ, the living examples of the former often exhibiting it, but the latter rarely or never.

[1] Read before Section C, British Association, Manchester, 1887.

[2] Sir P. Egerton, "Description of a Fossil Ray from Mount Lebanon (*Cyclobatis oligodactylus*)," Proc. Geol. Soc. vol. iv. pp. 442–446, pl. 5.

[3] F. J. Pictet, "Poissons fossiles du Mont Liban," 1850, p. 55, pl. x. fig. 4.

[4] J. W. Davis, "The Fossil Fishes of the Chalk of Mount Lebanon, Syria," Trans. Royal Dublin Soc. [2], vol. iii. (1887), p. 491, pl. xxi. fig. 1.

3. *There are no traces of median fins.*—In the Torpedinidæ, these fins are always more or less developed, one or two dorsals being invariably present, except in *Temera*, and in this genus the caudal fin is well represented. In the Trygonidæ, on the other hand, the presence of median fins is an exception to the general rule, dorsals never being met with, though sometimes replaced by barbed spines.

4. *The skin is armed with spinous tubercles.* Though not previously observed, the National fossils demonstrate very clearly that the dorsal surface of *Cyclobatis* was provided with at least one median row of prominent spines, and there are numerous minute prickles scattered both over the trunk and fins.

The larger tubercles are best seen in the type-specimen of *C. major* (the rough impressions of a few being shown in Miss Woodward's drawing, *loc. cit.*) ; in another fossil (B. M. No. 49514) which Mr. J. W. Davis has also labelled as pertaining to the same species; and in an incomplete specimen of *C. oligodactylus* (No. P. 99). The first of these shows that the series was continued forward almost as far as the pectoral arch, though the tubercles in advance of the pelvic arch appear to have been much smaller than those behind, and they succeed one another at short intervals. Each of these dermal defences is oval in form, rising into a sharp spine; and those placed more anteriorly have the base radially crimped, while the posterior examples seem to have been smooth, with the spine much more laterally-compressed and thorn-like, and the apex directed backwards. In one small fossil (No. 49557), of doubtful species, the tail has the appearance of being completely encased in rows of the tubercles.

The minute, irregularly-scattered prickles may be most satisfactorily studied in Nos. 49556, 49557, and 49514, their shape and characters being best displayed by the first-named, and their distribution by the two latter. Each of them seems to consist of a small erect, or backwardly-directed, spine, fixed upon a rounded, radially-marked base, being, in fact, a miniature of a larger tubercle, but higher in proportion to its size. There are some indistinct traces of these structures in Egerton's original specimen of *C. oligodactylus*; and the example of *C. major* (No. 49514) already referred to shows them densely arranged upon the margins of the pectoral fins. I have discovered no other dermal calcifications, except the teeth; and the "small hexagonal shining dermal ossicles," mentioned by Mr. Davis (*loc. cit.*), are evidently the superficial calcified tesseræ of the endoskeletal cartilage.

None of the living "electric rays" are known to have the slightest trace of dermal asperities, whereas the presence of these is a marked feature of certain Trygonidæ—especially the genera destitute of barbed caudal spines; and the facts just recorded are therefore corroborative of the inferences drawn from the three previous considerations, namely, that it is to the Trygonidæ rather than to the Torpedinidæ that *Cyclobatis* must be referred.

It would thus appear that there is still no evidence of the existence of Torpedoes in times anterior to the Eocene; and the earliest

undoubted members of this family hitherto discovered, are the species made known by Volta[1] and Baron de Zigno[2] from the fish-beds of Monte Bolca, near Verona.

---

## VII.—The Extent of the Hempstead Beds in the Isle of Wight.

By Clement Reid, F.G.S.

(Communicated by permission of the Director-General of the Geological Survey.)

OWING to the impossibility of making an accurate Survey of many of the flatter and Drift-covered portions of England, in the absence of sections, the light boring tools so extensively used by the Geological Survey of Belgium have been experimentally tried during the last few months in the Isle of Wight. The results arrived at are of so much interest that the Director has requested me to draw up this preliminary notice.[3]

The Hempstead Beds, which were thought to be confined to the outlier at Hempstead Cliff and another of unknown extent in Parkhurst Forest, prove to be much more important, indeed they occupy about half the Tertiary area of the Isle of Wight.

To find their limits series of borings were made, radiating in different directions from the highest points in Parkhurst Forest. These proved that the whole of the deposits there represented belong to the lacustrine Middle and Lower Hempstead Beds, for there was no trace anywhere of the *Corbula* or *Cerithium plicatum* zones. The "White Band" was met with in several places in the lower part of the Forest, but the outcrop of the "Black Band" (the base of the Hempstead Series) is a long distance away. It was found—with abundance of its characteristic fossils—less than half a mile from the Chalk, at Gunville, one mile west of Newport, and was traced eastward through Newport to Brading, always parallel with the Chalk, and dipping at high angles away from it. The northern limits pass near Ryde, Wootton, Osborne, and across the Medina to Gurnard, Newtown, and Hempstead.

Though no Hempstead Beds seem previously to have been noticed in the East Medina, they are very well represented there, and must be nearly 200 feet thick. At Wootton there is a small outlier, over 20 feet thick, of the higher estuarine beds full of *Cerithium plicatum*, *C. elegans*, and *Melania inflata*; but I have not yet succeeded in finding any relic of the *Corbula* Beds. Below this are mottled clays with *Unio*, etc., for about 50 feet, resting on thick sands, which in the East Medina seem to represent the base of the Middle Hempstead Beds. Beneath the sands is another series of mottled clays with *Paludina lenta* and *Cyrena semistriata*. These are about 80 feet thick, and have at their base the "Black Band." The Black Band and shales immediately above are very fossiliferous at Newport and

[1] Volta, "Ittiolitologia Veronese," 1796, p. 251, pl. 61.

[2] A. de Zigno, "Annotazioni Paleontologiche," Mem. R. Istit. Veneto, vol. xx. (1877), p. 452, pl. xvii.

[3] Full details will be given in the new editions of Mr. Bristow's "Geology of the Isle of Wight," and of the Geological Map—which, however, cannot appear for some months.

Wootton, and are full of the characteristic *Hydrobia Chastellii, H. pupa, Neritina tristis, Modiola Prestwichii*, etc.

Borings on each bank of the Medina prove that the Hempstead Beds cross the river unaffected by any fault, as also does the Bembridge Limestone at Cowes. The singular rise of the Osborne Beds at East Cowes, which has always been taken to indicate a fault, is caused by the intersection at right angles of two undulations, which produce a skew dip. Building operations at East Cowes show that the Limestone falls from Osborne to the bank of the Medina, where it can now be examined on the foreshore nearly opposite the exposure on the left bank of the river.

The Bembridge Marls also prove to be of considerably greater thickness than was formerly thought; they probably average about 120 feet.

---

## VIII.—Bursting Rock Surfaces.

By Prof. T. McKenny Hughes, M.A., F.G.S.

THE interesting note by Mr. Strahan in the Geol. Mag. for September, 1887, on explosive slickensides, reminded me of some similar phenomena which were not of unfrequent occurrence near Dent Head and Ribble Head in Yorkshire.

In the limestone quarry from which the black marble of Dent is procured the workmen found that, when they were quarrying the lower beds and struck the rock with a pick or bar, fragments flew up into the air with greater force than could be due to their blow and in an unexpected direction.

Also, when the tunnel was being made above Ribble Head, and the workmen were engaged upon the bed of rock which formed the floor of the tunnel, pieces used to burst off with a loud noise, so that some thought they had discovered a detonating shale.

The explanation in both these cases seemed to be that the bed which was apt to shell off in that unexpected manner rested on shale which yielded to the superincumbent weight on either side, and produced in the tunnel, or in the quarry, where the overlying rock had been removed, what would be called in a coal-mine a "creep" (see Woodcut).

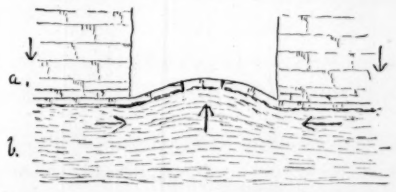



Diagram showing the manner of occurrence of Bursting rock at Dent Head and Ribble Head in Yorkshire. *a* rock. *b* shale; the arrows denote the direction of the pressure.

The shale behaves as a thick fluid or viscous mass, and transmits the pressure and motion. But in the cases to which I refer, a thin bed of the solid rock was left above the shale. This was not compressible, but, where, in the tunnel or in the centre of the quarry,

the weight of the overlying rock had been removed, it rose in a slight arch over the upthrust shale, and was thrown into a state of tension, so that when struck, chips and flakes, and sometimes larger pieces, would fly off. These pieces were in themselves quite sound. It was not that the whole mass was like Rupert's drops in a state of molecular unstable equilibrium, as suggested by Mr. Adam, and supported by Mr. Strahan in the case of the explosive slickensides, but it was rather analogous to the effect of drawing a knife across the outside curve of a bent stick; when jagged ends spring off and stand out straight in the original direction of the unbent stick—only in this case the fibrous character of the material prevents the pieces breaking away altogether as if it were rock. That the conditions in the case of the explosive slickensides were similar to those at Dent Head Quarry and the Ribble Head tunnel seems probable from the observation of Watson that "this phenomenon has not been noticed from slickensides where no shale is incumbent," and also from the suggestion of Phillips, "that the removal of one side of a vein would leave the remaining side in a condition of strain resembling that of a strung bow, with a tendency to bulge outwards into the workings. The undercutting would free, so to speak, one end of the bow."

But the observations at Dent Head Quarry and Ribble Head tunnel would show that it was not merely a bringing down of the mass of the vein stuff when undercut that was remarkable, but rather the tendency to shell off in chips and flakes over the whole surface. The beds at Dent Head and Ribble Head were approximately horizontal. Also it would appear from analogy that what the vein stuff did was not to offer a *material* more readily burst up, but a mass of the form and extent which could be bent by settlement of the surrounding rock so as to be thrown into a state of tension all over the exposed surface.

In connection with these inquiries we must always remember that time is an element in the bending of rocks, and that it is the rapidity of the action due to the artificial removal of the overlying mass that causes the rock to break rather than to sag and retain its curved form, as we see so commonly among the contorted strata where nature has applied the pressure more gradually.

---

## IX.—Note on *Hylæochampsa*.

By R. Lydekker, B.A., F.G.S.

In my paper on Crocodilia in the July Number of the Geological Magazine, pp. 310-311, I expressed my opinion that the characters given by M. Dollo in his description of the Belgian *Bernissartia* did not appear to me to afford grounds by which that form could be distinguished from *Hylæochampsa*, and I accordingly observed in a note that the *onus* of proving the distinctness of the former rested with its describer. In a note published on pp. 394-396 of the September Number of the Magazine, M. Dollo replies to this criticism, and shows conclusively that the Belgian form is entitled to specific, and very probably to generic distinction from the larger English one.

In respect, however, to the serial position of *Hylæochampsa*, there is no question whatever but that it must be regarded as one of the most specialized members of the Goniophiloid Crocodiles, and from the backward position of the posterior nares and the small size of the supratemporal fossæ that it is probably allied to *Bernissartia*. In my original paper I purposely refrained from quoting Sir R. Owen's description of the orbito-temporal region of *Hylæochampsa*, because, either from being misled by the broken edges of the bones in this region, or from not having at that time directed his attention to the importance of the features of this part, the Professor's description is not altogether satisfactory;[1] but the fact is undoubted that *Hylæochampsa* has the orbit in as complete communication with the lateral or infratemporal fossa[2] as in *Crocodilus* itself.

Assuming that *Hylæochampsa* be distinct from *Bernissartia*, the question will then arise whether the procœlous vertebræ of a small Crocodilian from the Wealden both of Sussex and the Isle of Wight described by Prof. Seeley in the Quart. Journ. Geol. Soc. vol. xliii. p. 212, pl. xii. figs. 7–8, under the name of *Heterosuchus valdensis*, may not belong to the former genus. This view occurred, indeed, to me at the time of writing my above-mentioned paper; but being then unable to distinguish *Hylæochampsa* from *Bernissartia* (in which the vertebræ are amphicœlous), it could not be advanced. In favour of it we may observe that it is highly improbable that the transition from the amphicœlous to the procœlous type of vertebræ precisely synchronized with the union of the pterygoids beneath the narial passage, and therefore that it is highly probable that *Hylæochampsa*, in which the posterior nares are only one step removed from the most specialized type, may have had procœlous vertebræ. I cannot, of course, put forward this suggestion as anything more than a possible, or perhaps probable, contingency; but it clearly shows how undesirable it is (as I hope shortly to show on another occasion) in the case of any particular group to form one genus on portions of the skeleton which are totally unknown in one already described.

Finally, I may observe that in the scheme of classification given on page 312 of my paper I proposed the name Crocodilia Vera for the united Eusuchia and Mesosuchia of Prof. Huxley; on further consideration, however, the term Eusuchia appears such a convenient one in opposition to Parasuchia, that I think it preferable to retain this old and well-known name in a wider sense, than to substitute for it the new one proposed.

[1] In his reply, M. Dollo enlists Mr. A. S. Woodward on the side of the Teleosauroid nature of *Hylæochampsa*; but I am authorized to state that the latter writer merely followed the lead of Sir R. Owen in this respect, and that having examined the specimen with me when I was writing the original paper, he was fully convinced of the relation of the orbit to the infratemporal fossa being of the type obtaining in the *Crocodilidæ*.

[2] By an inadvertence on p. 310, line 29 from top, of my paper, the words "*chez celui-ci*" are omitted at the conclusion of the quotation from M. Dollo; an omission which alters the sense of the whole passage.

## NOTICES OF MEMOIRS.

### I.—Recent Researches in Bench Cavern, Brixham, Devon.

By William Pengelly, F.R.S., F.G.S., etc.

As long ago as 1839 the workmen in a limestone quarry on the southern shore of Torbay, and adjacent to the town of Brixham, laid bare at the back of the quarry the greater part of a vertical dyke composed of red earth and angular pieces of limestone. The quarrying operations, then discontinued, were resumed in 1861, when the entire dyke was disclosed, and among the materials of an incoherent part of it which fell down, were found some hundreds of osseous remains, including skulls, jaws, teeth, vertebræ, portions of horns, bones, and pieces of bones, identified by Mr. W. A. Sanford, F.G.S., as relics of the Cave-Hyæna, Wolf, Fox (2 species), Bear, Wild Bull, Reindeer, Hare, and Arvicola (2 species). The Hyæna was by very much the most prevalent form; but there was nothing indicating that he found a habitual home there. Not a coprolite was met with, nor was there a single bone scored with his teeth-marks, or broken after any of his well-known modes. The entire absence of anything betokening the existence of man was equally marked. It must be remembered, however, that the finds then met with were all from a mass of heterogeneous material which had filled a fissure nowhere more than two feet wide, and in places not more than a very few inches—not from a cavern in the proper sense of that term.

Adjacent to the left bottom corner of the dyke was the mouth of a low narrow tunnel, having a floor of stalagmite and extending into the hill to an unknown distance, but certainly upward of 30 feet. The proprietor of the quarry declined to allow any scientific investigations to be made, stating that he meant to make such researches himself; but this was never done.

In September, 1885, Mr. W. Else, Curator of the Museum of the Torquay Natural History Society, obtained permission from the gentlemen into whose hands the property had passed, to make such explorations as he might find desirable both in the dyke and in the tunnel; and from that date he has spent on the work all the odds and ends of time he has been able to command. His more recent researches have been mainly carried on in the tunnel, where he found the stalagmite floor, from 6 to 12 inches thick, formed on a reddish cave-earth, having a maximum thickness of 14 inches, and lying on a continuous limestone basis. Beyond a few remains of Hyæna nothing of interest occurred in the stalagmite, but the contents of the cave-earth were more numerous and interesting. In July, 1887, 24 specimens of bone selected from Mr. Else's finds—21 being from the cave-earth in the tunnel and 3 from the dyke—were forwarded for identification to Mr. E. T. Newton, of the Geological Survey of England, who at the end of a very few days returned them with a list containing not only the names of the species to which they belong, but also those of the bones themselves.

Of the 21 from the tunnel one is a relic of a Fox, while all the

others are those of the Cave-Hyæna. The three from the dyke represent the Cave-Bear, *Rhinoceros tichorhinus*, and a species of Deer. Among the tunnel finds there were also three coprolites and a solitary part of a left lower jaw of Hyæna divested of its lower border—two facts indicating that the Hyæna occasionally visited the tunnel. Here also was found one, and but one, flint-flake tool. It has the white colour so prevalent in the tools found in the cave-earth of Kent's Hole, and was met with under circumstances admitting of no doubt of its having been made and used by a human contemporary of the Cave-Hyæna in Devonshire.

---

II.—On Some Important Extra-Morainic Lakes in Central England, North America, and elsewhere, during the Period of Maximum Glaciation, and on the Origin of Extra-Morainic Boulder-clay. By Professor H. Carvill Lewis, M.A., F.G.S.[1]

THE lakes so characteristic of all glaciated districts are due to several causes. Some few are due to an actual glacial scooping out of the rock floor, many to an irregular deposition of the drift, by which former watercourses are obstructed, and still others to the terminal moraine or to the glacier itself. These latter, known as *morainic lakes*, may be divided into *inter-morainic lakes*, *moraine meres*, and *extra-morainic lakes*, according to their position—back of, in, or outside—the moraine. Extra-morainic lakes, if dammed up by the ice front, are temporary in character, disappearing with the retreat of the glacier; but, as they may be of enormous extent if the glacier is large, they may produce deposits of much geological importance. Instances of such lakes occur in Switzerland, and ancient examples occur as well in Northern Germany, Asia, North America, and Central England. They are to be expected wherever a glacier advances against or across the drainage of a country. Mr. Belt supposed that Northern Asia was covered by a lake of this character, caused by the Polar glacier obstructing the rivers flowing north.

In North America, where the terminal moraine has been accurately mapped for thousands of miles, deposits of boulder-clay and erratics occur outside of the moraine, and have been supposed to be due to an older glacier in the first glacial epoch. But the general absence of striæ or of glacial erosion or moraines in this district prove that a glacier was not the agent of deposition. Nor are there any traces of marine life in the deposits. This extra-morainic boulder-clay is narrow in Pennsylvania, where the author has called it "the Fringe," but west of the Missouri is 70 miles wide; and in British America, between the great moraine called the "Missouri Coteau" and the Rocky Mountains, is 450 miles wide and over 1000 miles long. It only occurs where rivers had flowed *toward* the glacier, and is explained as the deposit of great temporary freshwater lakes dammed up by the ice front, the erratics having been dropped by icebergs.

Similar deposits occur in England outside of the terminal moraine,

[1] Abstract of a paper read at the Manchester Meeting of the British Association, September, 1887.

and have been the subject of much discussion; being held by some to be proof of marine submergence, by others to be the ground-moraine of a glacier. The "great chalky boulder-clay" is the best known of these deposits. There are serious objections to the two theories heretofore advanced to explain this, whilst the hypothesis of extra-morainic freshwater lakes, dammed up by the glaciers, is sustained by all observed facts. The most important of these lakes was one caused by the obstruction of the mouth of the Humber by the North Sea glacier, whose terminal moraine crosses that river at its mouth. This large lake reached up to the 400 feet contour line, and extended southward nearly to London, and westward in finger-like projections into the many valleys of the Pennine Chain. It deposited the "great chalky boulder-clay," and erratics were floated in all directions by icebergs. It was bounded in the Vale of York by the Stainmoor glacier, and Charnwood Forest was an island in it. At its flood period it overflowed south-westward by torrential streams into the Severn Valley and elsewhere, carrying the "Northern Drift" into the south of England. Other glaciers in England were bordered by similar but smaller lakes wherever they advanced against the drainage. Three such lakes were made by the Aire glacier, the largest of them extending to Bradford. The Irish Sea glacier caused many similar lakes high up on the west side of the Pennine Chain, and at its southern end north of Wolverhampton. The overflow streams from the most southern of these lakes joined those issuing from Lake Humber in the Birmingham district, characterized by a "commingling of the drift," otherwise inexplicable. An examination of the supposed evidences for glaciation, and for a great marine submergence in Central and Southern England, shows that neither theory is sustained by the facts. Thus, the supposed striæ on Rowley Rag prove to be rootmarks or ploughmarks; those reported at Charnwood Forest to be due to running water or perhaps icebergs; the supposed drift on the chalk wolds to be a local wash of chalk flints; the high level gravels on the Cotteswold Hills to be pre-glacial; the shells at Macclesfield, Moel Tryfaen, and Three Rock Mountain to be glacier-borne, and not a proof of submergence; the drift on the Pennine plateau of North Derbyshire to be partly made by icebergs floating in Lake Humber, and partly a decomposed Millstone Grit or Bunter Sandstone; and the Welsh erratics on Frankley Hill at a height of 800 feet to be due to a more ancient glaciation.

The conclusion that the glacial phenomena of England are due neither to a universal ice-cap nor to a marine submergence, but to a number of glaciers bordered by temporary fresh-water lakes, is in accordance with all the observations of the author in England and elsewhere.

*Postscript.*—Since the paper was read, of which the above is an abstract, I have found traces of the existence of a very much older series of glaciers than those here described. Since the period of these ancient glaciers, which in many places were more extensive than the modern ones, earth movements have occurred and erosion has removed almost all their deposits and generally obliterated the

striæ, so that the region subject only to the older glaciation now resembles a non-glaciated area. The glaciers and their bordering lakes described above should therefore be considered as belonging to the second or last glacial epoch.

---

III.—The History and Cause of the Subsidences at Northwich and its Neighbourhood, in the Salt District of Cheshire. By Thos. Ward, Esq.

THE frequent occurrence of subsidences in the neighbourhood of Northwich makes it desirable to learn their history and cause.

Northwich overlies extensive beds of salt. These occupy about three square miles. The first or 'top' rock-salt lies at a depth of about fifty yards from the surface, and is covered by Keuper marls, and these by the drift sands and marls. Between the two beds of salt there are 30 feet of indurated Keuper marl. The second, or 'bottom' rock-salt, is over 30 yards in thickness. These beds of salt occupy the lowest portion of an old Triassic salt lake.

The first bed of rock-salt was discovered in 1670, the second in 1781. From about 1730, at which date the river Weaver and the Witton brook were rendered navigable, until after 1781, all the rock-salt mines were in the 'top' bed, and the whole of these with one exception have been destroyed, and in almost every case by water, leaving funnel-shaped nearly circular holes. These are now filled with water and are known as 'rock-pit' holes. The rock-salt mines are now in the lower bed and very rarely fall in. When worked to the boundary, water and brine, either or both, break in or are let in, and the mines are utilized as huge reservoirs.

The falling in of a rock-salt mine is a very rare occurrence, and subsidences of this kind do not give rise to the reports which are met with in the newspapers. The first reported destruction of a mine was in 1750, and from that date to the end of the eighteenth century every two or three years a mine collapsed. In the present century, at considerable intervals of time, collapses of mines have occurred, but these with scarcely an exception were old abandoned 'top' mines.

The subsidences which are so destructive in the town of Northwich and the neighbourhood are entirely caused by the pumping of brine for the manufacture of white salt. It was only about 1770 or shortly afterwards that the first sinking was noticed; since that date subsidence has gone on very rapidly, and much destruction of property has resulted. Large lakes or 'flashes,' one of more than 100 acres in area, and of all depths up to 45 feet, have been and are being formed. Prior to 1770 not more than 30,000 tons of salt were sent down the Weaver navigation; by the end of the century it reached 100,000 tons, and in 1880 had increased to 1,087,000 tons. The whole of this salt was taken off the surface of the first bed of rock-salt by the solvent action of water. In fact, water is the instrument used to mine and carry off the salt to the pumping centre. The brine pumps set up a circulation of the salt water or brine lying on the rock-salt, which flows to the pumping centres. The brine thus removed is replaced by fresh water, which on its

passage to the pump saturates itself taking up sufficient salt to make a solution containing about 26 per cent. of salt. This continual removal of salt from the surface of the rock-salt lowers it, and the overlying earths either follow the diminishing surface continuously, or else after remaining suspended for a time suddenly fall into the cavity from which the water has extracted the salt. The brine currents on their way to the pumping centres form deep valleys or troughs, and the surface of the ground overlying forms a facsimile of these hollows. The property on the sloping sides of the valleys is pulled to pieces and destroyed; the windows and doors all get out of form owing to the unequal sinking of the various portions of the house. When, owing to the different nature of the marls and the abundance of sand overlying them, a sudden sinking takes place, the hole extends to the surface and swallows up anything upon the surface—as a horse in a stable, barrels of beer in a cellar, or water butts and other utensils in a yard. The damage done to property is enormous, but thus far no human life has been lost. The most serious part of the matter is that the brine-pumper takes not only his own salt in solution, but that of all his neighbours over whose salt beds the water flows, and neither asks their consent nor pays them for the salt thus obtained. Worse even than this, the owner of the property overlying the brine 'run' suffers most serious damage to buildings, etc., but can obtain no compensation, because amongst the number of brine-pumpers he cannot prove who is doing the particular mischief complained of. This peculiar phenomenon of subsidence in the salt districts is worthy of more consideration than it has hitherto received from scientific men.

---

IV.—On the Occurrence of Porphyritic Structure in some Rocks of the Lizard District.[1] By Howard Fox and Alex. Somervail.

Prof. Bonney has described a porphyritic diabase which is seen on the shore at Polpeor; it cuts, in an intricate manner, through micaceous and hornblendic schists. The authors have traced this rock further, and have recognized a porphyritic structure in many dykes and intrusions along the coast which cut through the serpentine, and also in the darker bands of Professor Bonney's 'granulitic group.'

Descriptions of these various localities were given and illustrative specimens exhibited. The crystals of felspar are found to be most numerous in those rocks which lie in the closest proximity to the gabbros and serpentine. They have their long axes at various angles, and are mostly small except at Parn Voose, Cavouga, and Green Saddle. The felspathic and hornblendic lines often circle round the crystals.

Without discussing any theory as to the true nature and origin of the whole of the schists, the authors think that the porphyritic structure so prevalent in the dark bands of the 'granulitic group,' in many of the micaceous and other rocks, as also in the later intrusions cutting the serpentine, indicate an igneous origin for many rocks hitherto regarded as schists.

[1] See Mr. Teall's paper, *ante*, pp. 484–493.

## CORRESPONDENCE.

### REMAINS OF *BOS PRIMIGENIUS* RECENTLY FOUND AT SOUTHAMPTON.

Sir,—During the progress of the excavation for the purpose of forming a new deep water dock of eighteen acres at Southampton, a fine specimen of the horn cores and part of the skull of *Bos primigenius* has been found.

The river mud with which the excavation begins is of a thickness varying from ten to fifteen feet, below which a bed of peat resting on dark angular flint gravel occurs. Both the peat and the gravel vary in thickness, as the gravel is found more or less in ridges, in the hollows of which the peat attains its greatest depth. It was from one of these thick masses of peat that the remains of *Bos primigenius* were met with at a depth of nearly twenty feet below the surface of the mud, which formed the bed of the tidal estuary at this spot.

The skull was found in one piece, and includes the frontal, occipital, temporal, sphenoid (with both wings), and tympanic bones, with fragments of the pterygoids, and of the ethmoids.

The temporal fossæ are preserved, and the roof of one orbit, and part of the other; the zygomatic arches are incomplete.

The breadth of the forehead, across the centre, is ten inches, and between the orbits about twelve inches. The length of the forehead as preserved is eleven inches, and the length from the frontal crest to the base of the occipital bone is ten inches. The circumference of the cores of the horns at their roots is sixteen and a quarter inches, and the length of the cores round the curvature about twenty-nine inches. The width apart of the horn cores from tip to tip is thirty-four and a half inches.

The specimen has been placed in the Museum of the Hartley Institution, Southampton.

T. W. Shore.

### PALÆONTOLOGICAL NOMENCLATURE AND THE TRINOMIAL SYSTEM.

Sir,—An answer given not very long ago in an Examination paper was as follows, "Physical Geography is the work of God, Geology is the work of man." No doubt the candidate who wrote this answer failed to receive full marks; but since the matter was brought to my notice, it has frequently occurred to me that the reply was not altogether inappropriate. Geology and Palæontology are suffering from such an infusion of new and hard names that the ordinary reader and even the hard-working student are often bewildered and baffled in their efforts to comprehend the progress of knowledge. It is not my intention now to discuss any of the new terms applied to our formations and their subdivisions; suffice it to say that most of the suggestions to replace old and well-understood names would, if adopted, be more likely to place obstacles in the path of the inquirer than to assist or encourage his studies. What even more painfully stirs me at the present time is the multiplication

of generic or subgeneric names of Ammonites, and the confusion that appears to have arisen concerning what have hitherto been regarded as recognizable species.

It is indeed difficult for the "general geologist" to understand and remember the subgeneric names of Ammonites, especially when the form known as *Harpoceras concavum* has been recently changed again to *Lioceras concavum*, and *H. Murchisonæ* has become *Ludwigia Murchisonæ*. One cannot help wondering what other changes may be in store for us. It is, however, still more perplexing to be told by one who has devoted especial attention to the subject, and who is in every way qualified to speak with authority, that the form which is "called by D'Orbigny, Wright, and others *Am. serpentinus*, and is so labelled in museums and private collections, is the *Ammonites falcifer* of Sowerby." (See S. S. Buckman, Geol. Mag. Sept. 1887, p. 396.) What is then to become of our "*Serpentinus*-beds"? Again, the same palæontologist tells us that the occurrence of *Ammonites Jurensis* in England is doubtful, in fact he has never yet ascertained its presence in our strata. (Proc. Cotteswold Club, vol. ix. part 2, 1887.) What then is to become of our "*Jurensis*-beds"? Once more, the recognition of the true *Ammonites Sowerbyi* appears to be a source of great difficulty to judge by the remarks made in a recent volume of the Palæontographical Society. (Hudleston, Introduction to Gasteropoda of the Inferior Oolite.) Even the "*Sowerbyi*-beds" are in trouble!

The question that perhaps naturally arises to an outsider is this, cannot these well-known specific names be applied in a sufficiently comprehensive way to include the forms which the older authorities recognized under the names of *A. serpentinus*, *A. Jurensis*, and *A. Sowerbyi*, respectively?

To go further, would not the adoption of the trinomial system meet all requirements, and be the means not only of doing justice to the more minute and exceedingly important observations made now-a-days, but also of placing the results of this detailed work in a manner more intelligible to the "general geologist"? It would seem likely under present circumstances that some collective grouping of the many species now made must eventually take place, if any individuals except the specialists in each department are to follow the progress of palæontology, or attempt the naming of their fossils: and this grouping might be done under the trinomial system, better, it appears to me, than under the system which introduces subgeneric names. So far as the geologist is concerned, he simply requires a definition of specific characters, and a key to the distribution of each species in time and space. Where particular varieties are confined to special horizons, he can obtain this precise information on the trinomial system. Moreover, the adoption of that system would fulfil all the requirements of the biologist. No doubt many more specimens are available now for study than was formerly the case, and it becomes more and more difficult to draw rigid lines; but there seems to be a tendency to confine specific characters within narrower limits than heretofore, and this perhaps is the real source

of the difficulty. I should feel much grieved if these remarks appeared to convey any slight whatever on the careful work of modern palæontologists; but my impression is that the object of their labours will be to a serious extent frustrated if their results are published in too complex a form for the "general geologist." Having said so much about changes of names, perhaps I may be pardoned if I sign myself,

ROB. W. HADDOW.

BANBURY, 8*th Sept.* 1887.

## CHERT IN IRISH CARBONIFEROUS ROCKS.

SIR,—Chert is not, as supposed by Dr. Hinde, a definite characteristic of the Irish Upper Carboniferous Limestone (see chapter v. Manual of the Geology of Ireland, C. Kegan Paul & Co., 1878). Where this limestone is fully represented as in Co. Limerick, etc., the "lower cherty zone" is there best developed; and it occurs *in the lower limestone*, between the "lower shaly limestone" and the "Fenestella Limestone." A second conspicuous zone for chert lies between the Fenestella Limestone and the upper limestone, when of the "Calp type." In the upper limestone of Cork and Kerry there are layers and nodules of chert, but in Limerick, Tipperary, and part of Galway it is rare, while in the rest of Galway and in Clare it is more common. In part of Leinster, between the upper limestone and the Coal-measures lower shales, there is a cherty zone, but in the rest of Leinster and in Munster in all the known sections of the junction of the Limestone and Coal-measure shales, this cherty zone is absent. In Ulster, however, especially Fermanagh, where sections can be seen, this cherty zone is well developed and of a character similar to that described by Dr. Hinde as characteristic of the Yoredale Series, Yorkshire.

According to my experience chert is as frequent, if not more so, in the Lower, as in the Upper Irish Carboniferous Limestone. When it occurs in zones, it is usually accompanied by shaly beds, and is more or less friable; but when in compact limestones like those of the "Burren type," it stands out conspicuously like the nodules, lentils, and layers of flint in the chalk, as can be seen in innumerable places in Cork, Kerry, Clare, Sligo, Fermanagh, etc.; near Athenry, Co. Galway, in a railway-cutting, there is a thick bed.

As Dr. Hinde has been making researches as to the origin of chert, I would specially direct his attention to the chert lentils perpendicular to the stratification in Benmore, Co. Fermanagh, to which attention was first drawn by Thos. Plunkett, M.R.I.A., of Enniskillen, in a paper read before the Royal Dublin Society. Those mentioned in his paper occur in Benmore, but I have since observed them in Belmore and other places in that county. They are lenticular masses in height and depth, and have all the appearance of ordinary chert. I take it that they are the filling in of shrinkage fissures along a line of partial rupture. I would also draw his attention to the lower and middle cherty zones in the Co. Limerick, both of which are remarkable Palæozoic breaks, as in the intervening rock, "Fenestella Limestone," the fossils are quite distinct and much more

abundant than in the strata above (Calp) and below (lower limestone with shale partings). I would also draw his attention to the papers published by the Boston Society on the island of Cuba, which I suspect might throw some light on the subject. As suggested in previous writings I suspect that the cherty zones in the Irish Carboniferous Limestone, especially that between the Fenestella Limestone and the Calp, must have some connection with vulcanicity.

Years ago Jukes got chert from Queen's Co., Limerick, Clare, etc., examined by Sorby, and I think I remember that he published about them.

Geological Survey of Ireland. G. H. Kinahan.

---

## *RE* "EXPLOSIVE SLICKENSIDES."[1]

Sir,—I should like, if I may, to add a few facts which seem to closely bear upon the subject of Mr. A. Strahan's interesting article in the August Number of your Magazine. They are these:—In driving, exploring, or "opening-out" headings in certain seams of coal, loud reports are very frequently heard, which are often accompanied by the bursting-off from the sides of the excavations of large blocks or masses of coal. The noise made by such "explosions" or reports may be likened to artillery, and often causes men to run out of the place with alarm. Now, these "bumps," as the miners term them, generally occur in situations where the strata are much faulted by dislocations, and increase in importance with depth or thickness of cover. They probably happen most frequently and loudest in single drifts or headings, or those formed in advance of the general workings of the mine; and it is where these excavations are formed in the lower part of the coal-seam that the "bumps" are heaviest and produce greatest effects. Such an instance occurred a few years ago in one of the pits of the Moira Collieries close here, when a sudden and very severe bump completely displaced and shattered a single-brick "brattice"-wall (or partition, dividing the excavation longitudinally for ventilating purposes) for a length of about 24 feet. This wall was, as it were, completely *blown* out, and the men in the place were "jumped-up" off the floor, but not hurt. The wall was about three feet high and built with mortar. Again, in excavatimg the main roadways in the solid coal in the thicker seams of South Staffordshire, very severe bumps take place, and have been known to suddenly displace hundreds of tons of coal, by throwing them off the sides into the road. But in the ordinary course of coal-getting, especially by the method called the "Longwall" (*i.e.*, where all the seam is extracted by one operation), loud reports with bumps are of every-day occurrence, and now and again they have the effect of knocking out the props and sprags (wooden supports to roof and sides) and bring down a quantity of stuff. Also, during the operation of "holing" (under-cutting the coal-seam preparatory to breaking it down), the coal will keep on bursting itself off in little fragments from the face of the excavation with loud explosive reports, often putting the men's candles out. When the coal does this, it is said to have plenty of "life" in it, or "it keeps talking to you."

[1] See Prof. T. McKenny Hughes' article, *ante*, pp. 511–512.

When in the mine alone and all work is suspended, I have frequently heard strange and unearthly (?) sounds, such as rattlings, scratchings, knockings, etc.—noises called "nackings" by the men. In Yorkshire I have heard of bumps of such magnitude taking place as to throw down large areas of roof in worked-out parts of the pit, and which created a blast in the air of the mine strong enough to knock men over, upset tubs, blow open doors, put out lights, and cause much havoc.

Subterranean rumblings, as is well known, have for several years been heard, and felt too, beneath and in the vicinity of the town of Sunderland; but these are considered to be due, not to coal-mining, but to the dissolution of the magnesian limestone by water which is constantly being pumped through it.

Now, it appears to me, that there is one common cause for all these "explosions," "bumps," "nackings," etc., which is simply this: the upsetting, by the excavation, of the equilibrium of the strains or pressures holding everything fast and firmly together—the removal of the support thereby causing the rocks to get relief and to fly off or apparently to explode. I look upon the phenomena as *miniature earthquakes* in fact.[1] I question very much whether gas has anything to do with these bumps, etc., even in coal-mines, but that they act upon the gas is exceedingly probable. The phenomena are certainly often very striking, and would seem to be worthy of much more attention than they have received. With Mr. Strahan's last paragraph I quite agree.

W. S. Gresley, F.G.S.

Overseal, 8 *Sept.* 1887.

---

## THE DATE OF THE ICE AGE.

Sir,—Some time ago you inserted a letter of mine in which I contended that a high eccentricity of the earth's orbit and winter aphelion would not produce all the effects which Dr. Croll assigned to them. I venture now to give some reasons for thinking that the Glacial Period did not occur so long ago as Dr. Croll's theory supposes. His principal maximum of eccentricity took place 800,000 years ago, while the last large maximum was about 210,000 years ago. Can the Ice Age have been as remote as this?

I have just returned from a visit to the Lake District, the glacial phenomena of which have been very fully described by Mr. J. Clifton Ward. The traces of ice-action along the sides of the mountains bordering the Valley of Borrowdale are remarkably numerous and well-defined. The sides of these mountains are usually steep and pretty bare, and the rainfall of the district is enormous. At Seathwaite, situated at the head of the valley, Sir John Herschel gives the annual rainfall at 141 inches, and Ramsay at 113 inches. No doubt the rocks are hard volcanic rocks which would stand a good deal of wear; but would the ice-markings be as

[1] I recollect seeing it stated in a newspaper a few years ago that the wife of the colliery manager was disloged from her seat in the house in Nottinghamshire at the same moment that a very heavy "bump" occurred in the workings of the colliery below, which at the time was, by some, attributed to an earthquake.

distinct as they are if these steep mountain-sides had been exposed to annual rainfall of 100 inches for the last 200,000 years?

Above Grasmere there is a small lake, know as Easdale Tarn, which seems to have been partly formed by a terminal moraine, while earlier ice-markings down the valley seem to indicate that the glacier formerly pursued the same course which the stream from the tarn now follows. Though the drought of the season had been remarkable this stream was not a very small one, yet the work of erosion done by it since the Glacial period was not of a very startling description. It was not what I should expect a rapid mountain-stream (though checked by a small tarn) to effect in 200,000 years.

Such phenomena are by no means peculiar to the Lake District. The great fall of Niagara seems to be an example. There is, I believe, no trace of an earlier post-glacial river-channel. On the contrary, the ice-markings almost down to the water's-edge above the fall seem to show that the glacier followed the same track as the river. The river must, therefore, have commenced cutting out of the gorge as soon as the ice-cap cleared away. But Sir Charles Lyell estimated the time necessary to cut out this gorge at 35,000 years, while others have placed it as low as 12,000. Professor Winchell has estimated the time required to cut out the gorge below the falls of St. Anthony at 8000 to 10,000 years. I am not aware that there is any reason to think that this excavation did not commence until long after the close of the Ice Age.

Man probably existed on the earth in the Glacial, if not the Pre-Glacial, era. But is there any reason to suppose that he existed for at least 200,000 years without making any solid progress in civilization, and then suddenly made the great advances (emanating apparently from more than one centre) which has taken place in the last 10,000 (or perhaps 6000) years? It is not a case of an anthropoid ape slowly developing into a man during a period of 200,000 or 800,000 years; for the earlier skeletons appear to be those of fully-formed men.

For these reasons I think Dr. Croll refers the Ice Age to too remote a period. Further researches on the amount of post-glacial erosion and the erosive power of the streams or rivers engaged in it ought, I think, to enable us to decide the question one way or the other with a tolerable degree of certainty.

DUBLIN, *Sept. 5th*, 1887. W. H. S. MONCK.

---

## DR. HINDE ON THE ORIGIN OF CARBONIFEROUS CHERT.

SIR,—Permit me to reply to the article by Dr. Hinde, F.G.S., which appears in the GEOLOGICAL MAGAZINE for the present month (No. 280, p. 435). As I had an opportunity when attending the meeting of the British Association in Manchester of hearing the paper read in Section C, and as I had previously had the pleasure of a visit from its author in this city, I was not unprepared for the onslaught which afterwards took place. I have no wish to maintain a position which subsequent investigation has shown to be untenable, or which requires readjustment; and I am, therefore, quite ready

now to admit, what I stated in Manchester, that in examining the slides of chert under the microscope, I had, at least in many instances, mistaken forms of sponge-spicules for those of Crinoid stems. Nor was this, I submit, at all surprising when we recollect that these organisms are often very vague, and that the bands of chert occur intercalated with beds of limestone abounding in stems, ossicles, and plates of Crinoids. It was not unnatural, therefore, that I should have supposed the little discs seen in the chert-sections under the microscope to be minute cross-sections of these stems or ossicles.[1] Dr. Hinde's great experience in the examination of the sponge-structures of the Cretaceous beds has given him an advantage in this line of investigation which certainly has not fallen to my lot; consequently, when on examining my slides in this office, he stated that the forms were those of sponge-structures, I accepted his statement without question.

Dr. Hinde's recent investigations undoubtedly show that siliceous sponge-structures enter far more largely into the composition of Carboniferous chert than has hitherto been suspected, and even, that they exceed in numbers other organic forms; all this I now willingly concede. But I am not prepared to go to the full length of Dr. Hinde's demands, as I understand them, nor to abandon as untenable the proposition that much of the silica of Carboniferous chert has been derived by a transmutation process from the waters of the ancient seas. Not only are there to be found forms, such as those of Corals, Brachiopods and Polyzoa and ossicles of Crinoids, originally calcareous, now occurring silicified in the chert, but the amorphous cementing material of the organic structure which may be supposed to have originally been calcareous has now been transmuted, or may have been directly deposited from the waters under such favourable conditions as those supposed by Mr. Hardman and myself in our original memoir.[2] A similar conclusion has been arrived at by Prof. Renard by a process of investigation analogous to, though quite independent of, that pursued by ourselves. Whatever doubt I might have entertained in regard to my own conclusions, I cannot extend to those of so competent an observer as Prof. Renard. Let me ask Dr. Hinde, does he deny the possibility of siliceous bodies or masses having been formed by the transformation process? If so, he is confronted by the evidence of a large number of the ablest observers, both British and Foreign, amongst whom may be mentioned Bowerbank, Rupert Jones, Sullivan, Sterry Hunt, and Bischof.[3] If so, it is *Hinde contra mundum*; and let me say that these observers appeal to Nature as well as does Dr. Hinde himself.

I feel obliged to Dr. Hinde for having called my attention to the fact that Professor Sollas had previously identified siliceous sponge-spicules in the chert-sections which I had forwarded to him for

[1] From what Dr. Hinde has stated in his original paper (Phil. Trans. 1885, note, p. 433), it would appear that a more competent observer than myself has fallen into a similar error; from which it will be inferred that it is a matter of much difficulty, and requiring great experience to distinguish the one from the other.

[2] Scientific Transactions, Roy. Dublin Society, vol. i. new ser. (1878).

[3] Bischof: "Chemical and Physical Geology," Cavendish edit. vol. ii. p. 486, *et seq.*

examination. When I wrote my paper for the Royal Society, I had altogether forgotten this circumstance, which I much regret; a copy of the paper itself had been carefully laid aside by me for reference, and suffered the fate of most such papers.[1] Having, however, now referred to this document, I will put it in evidence on the question now discussed, and the reader will hear what Prof. Sollas has had to say. The author examined five of my slides of chert-sections under the microscope, and states as the result of his examination; "in the first place, to completely confirm his (Prof. Hull's) clear descriptions of the appearances presented by them (the chert-sections); and next, to establish the truth of my supposed detection of sponge-spicules," as shown in the plate accompanying my original paper. This is very valuable testimony.

As to the question of the geological position of the so-called "Yoredale Series," I have only to say that I have used the term as it is understood on the Geological Survey throughout the wide district where, in conjunction with some of my colleagues, I mapped these beds some years ago in South Lancashire, Cheshire, Derbyshire, and the adjoining parts of Yorkshire, an area of not less than 2000 square miles. What may be the exact relations of these beds to those of the Valley of the Yore as described by Phillips, I am not prepared to say. It is well known that the Lower and Middle Carboniferous strata undergo considerable alteration both in character and thickness as we proceed northwards from Derbyshire and Cheshire; and I can only now refer Dr. Hinde to my paper on the Classification of the Carboniferous Rocks published in the Quarterly Journal of the Geological Society, vol. xxxiii. for my views on this subject.

In conclusion, I have to add, that if I have misquoted Dr. Hinde, as he affirms, I can only express regret, as I took special care not to do so, as will be seen by referring to my paper in the Proc. Roy. Soc. vol. xlii. p. 305. My late valued colleague, Mr. Hardman, whose name occurs in this controversy, is not now with us to take his share therein, but I feel convinced he would have concurred in what I have written.

EDWARD HULL.

GEOLOGICAL SURVEY OFFICE, DUBLIN, *7th Oct.* 1887.

## OBITUARY.

### JOHN EDWARD LEE, F.S.A., F.G.S., ETC.

BORN DECEMBER 21ST, 1808; DIED AUGUST 18TH, 1887.

DEVONSHIRE has lost another excellent geologist and antiquary in Mr. John Edward Lee, of Villa Syracusa, Torquay. Mr. Lee was born at Newland, Hull, Dec. 21st, 1808. His father having died when he was very young, he was brought up by two uncles, Avison and John Terry, and at sixteen he entered their shipping office in Hull. From the earliest period of his life he took an interest in science, beginning with Entomology, and while living

[1] Prof. Sollas's paper was published in the *Annals and Magazine of Natural History* for February, 1881.

at Hull he took an active part in the Royal Institution there; frequently at the end of the day's work, he would shut himself in the Museum, and stay far into the night arranging the specimens it contained.

His health failing, he travelled abroad, first in Norway and Sweden, afterwards in Russia and other parts of the continent. During these tours he sketched, and also mastered French and German thoroughly.

In 1841 he entered the Iron Works (J. J. Cordes & Co.) of Newport, Monmouthshire, where he spent the best years of his life.

In 1846 he married Miss Gravely, of Torquay, and they resided at the Priory, Caerleon, till 1868, when anxiety for Mrs. Lee's health decided his removal to Villa Syracusa, Torquay; but he still constantly went back to Monmouthshire for many years.

During all the years of his residence at Caerleon, and later at Torquay, until failing health compelled him to abandon many of his cherished pursuits in life, he worked steadily and uninterruptedly at various branches of science, principally at Geology and Archæology.

He was one of the founders of the Monmouthshire and Caerleon Antiquarian Society, to the Proceedings of which he frequently contributed. He also aided in the formation of the Museum at Caerleon, publishing, under the title of "*Isca Silurum*," an illustrated catalogue of the Roman remains discovered at Caerleon, the ancient capital of the "Silures."

He exchanged fossils with geologists in all parts of the world, and carried on a large correspondence with many foreigners, who had either visited his collection at Caerleon or Torquay, or whom he had met during his numerous continental travels, or others in America and elsewhere with whom he had no personal acquaintance. All his journeys were undertaken with a scientific object, and he was in the habit of carrying small sketch-books with him when travelling, the contents of which he utilized in his publications, many of his sketches appearing in "The Note-Book of an Amateur Geologist," published in 1881.

His principal work was a translation and revision (assisted by the author) of Dr. Keller's Lake Dwellings of Switzerland, printed in 1866, and a second edition (in two volumes) in 1878; all the plates for this work, 206 in number, were drawn by Mr. Lee for the English edition, and illustrate more than two thousand five hundred objects, obtained from between two and three thousand separate lake-dwellings." Mr. Lee's other works are, "Roman Imperial Photographs" and "Roman Imperial Profiles" (the latter being a series of more than 160 lithographic profiles enlarged from coins), both published in 1874.

A translation of Conrad Merck's Excavations at the Kesslerloch, near Thayingen, Switzerland, a cave of the Reindeer period, followed in 1876; and an English version of Prof. Roemer's Bone-cave of Ojcow in Poland in 1884.

One of Mr. Lee's most interesting geological expeditions was made to Italy in 1868, in company with one of his earliest friends, Prof. John Phillips of Oxford, to study the phenomena of Vesuvius, then in active eruption.

Ten years later (1878) the writer of this notice had the pleasure to accompany Mr. Lee to the Eifel district, where, being happily joined by Prof. Ferdinand Roemer, of Breslau, the historian of the Devonian rocks of this region, a delightful fortnight was spent in collecting the fossils of Gerolstein, Prüm, and other localities.

Mr. Lee contributed several important papers to the GEOLOGICAL MAGAZINE on points in Devonian geology which he had worked out; he was the original discoverer of many fossils described by the late Mr. J. W. Salter, F.G.S. (as *Homalonotus Johannis*, etc.)

He gave his most valuable and extensive collection, contained in 31 cabinets and comprising upwards of 21,000 specimens, to the British Museum (Natural History), in 1885. This collection not only embraces a large series of British fossils from all formations, many of which have been figured and described, but a most valuable and instructive collection from almost every important European locality where fossils abound.

Although his bodily powers began of late years to fail, his intellect remained bright, especially on all matters of science, to the last, and after he failed to write, he dictated and signed many letters, giving clear and accurate scientific information to correspondents, and he was full of plans and ideas for the furtherance of science up to the end.

Mr. Lee was a Member of the British Association, a Fellow of the Society of Antiquaries, and a Fellow of the Geological Society of London.

---

## SIR WILLIAM VERNON GUISE, BART., F.L.S., F.G.S.

BORN 1816, DIED 1887.

SIR WILLIAM GUISE was the eldest son of the late Gen. Sir John Wright Guise, Bart., one of the most distinguished Peninsula officers, by his marriage with Charlotte Diana, daughter of the late John Vernon, Esq., of Clontarf Castle, County Dublin. He was born in the year 1816, and succeeded to his father's title in 1865. He was a Magistrate and Deputy-Lieutenant for Gloucestershire, and served as High Sheriff of that county in 1872. He was also a retired Lieutenant-Colonel of the Royal South Gloucestershire Militia. Sir William married in 1844, Margaret Anna Maria, daughter of the Rev. D. H. Lee-Warner, of Walsingham Abbey. He is succeeded by his eldest surviving son, William Francis George, who was born in 1851.

Sir William Guise was elected a Fellow of the Geological Society in 1841; and although not a founder, was for many years one of the most active members of the Cotteswold Naturalists' Field Club. Only last year he retired from the office of President, which he had held for 28 years. He had a wide general knowledge of Geology, Conchology, Botany, and Archæology, and there were few objects or places of interest in Gloucestershire with which he was not acquainted: thus he was eminently qualified to direct the Excursions of the Club, while his hearty and genial manners contributed much to the enjoyment of the meetings. Sir William Guise died on the 24th September, at his residence, Elmore Court, near Gloucester.